COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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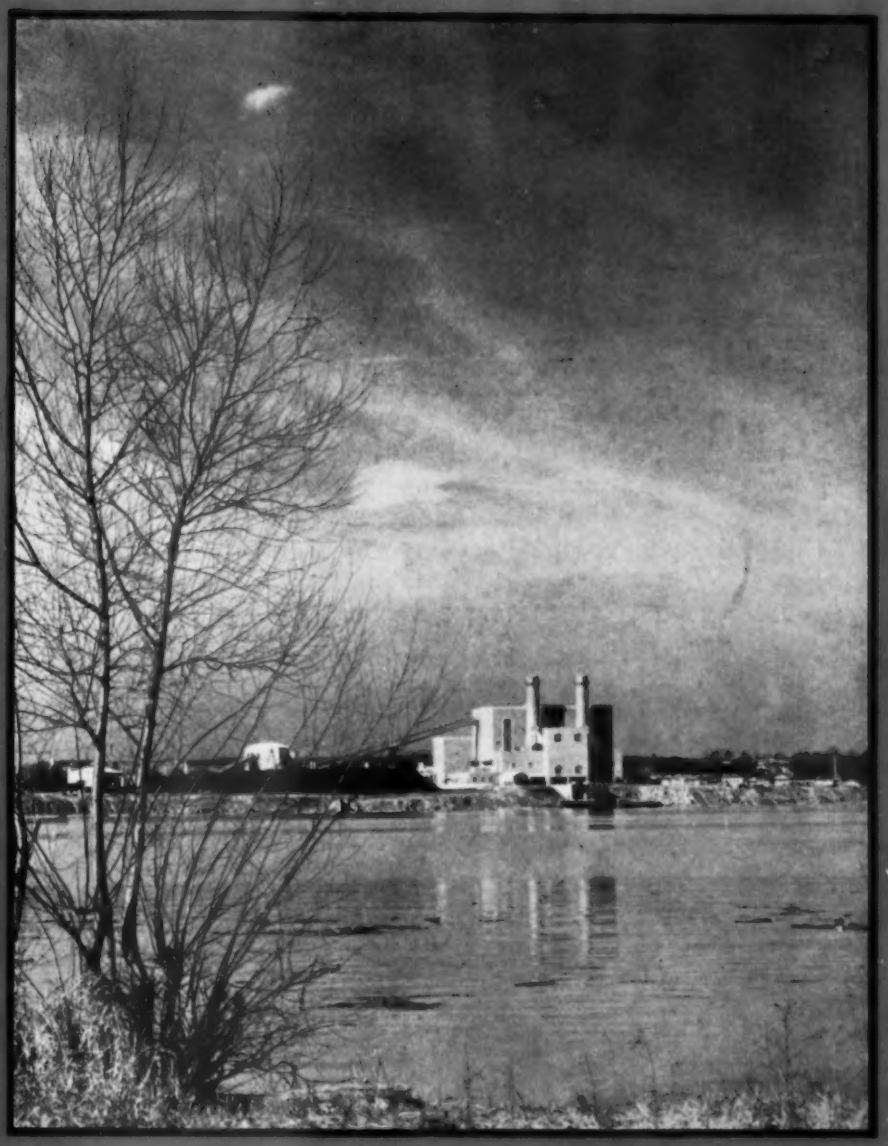

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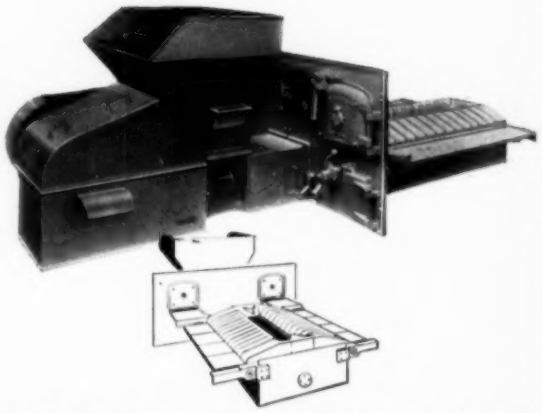
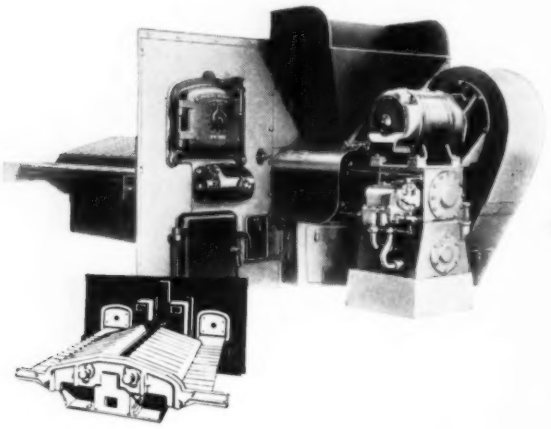
A compact, self-contained underfeed stoker. Designs for either anthracite or bituminous coal. Alternate fixed and moving grate bars assure lateral distribution of fuel and maintains a clean porous fire. Cantilever dump grates simplify ash removal. Integral forced-draft fan permits positive regulation of air-coal ratio. Variable-speed transmission. Automatic control is standard. Timken bearing equipped. Alemite lubrication.

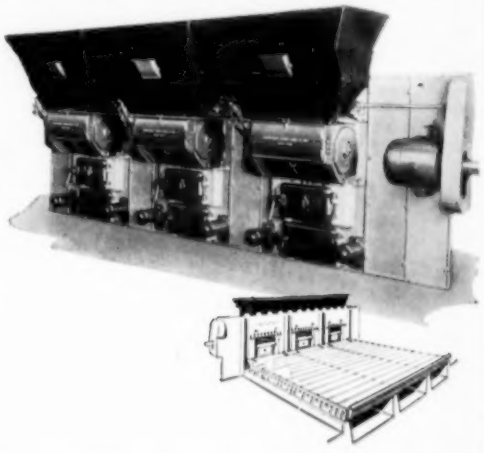




TYPE E STOKER **Application Range — 150 to 600 boiler hp. (Approx.)**
A single-retort, underfeed stoker designed to burn a wide variety of bituminous coals, particularly those having caking and coking characteristics. Has ram type feed and reciprocating sliding bottom. Hollow, air-cooled grate bars are arranged in an alternately fixed and moving relationship to condition the fuel bed and assure its steady movement to the dump trays. Air supply is under zoned control. Provision for air over the fire. Available with steam, electric or hydraulic drive.

SPREADER STOKER **Application Range — 150 boiler hp. up to units producing 200,000 lb of steam per hr, or more.**

Available in both dumping grate and continuous discharge types, this simple, rugged stoker is designed to burn a wide variety of coals. Hopper, feeding and distributing mechanism, variable-speed drive and motor are combined in a compact unit. Grate surface is zoned for regulating air admission and to facilitate cleaning. All parts subject to wear are readily accessible. Rate of fuel feed and air supply may be regulated over a wide range and are readily adaptable to automatic control.



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ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT

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Vol. 21 **No. 9**

March, 1950

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COMBUSTION is indexed regularly by Engineering Index, Inc.

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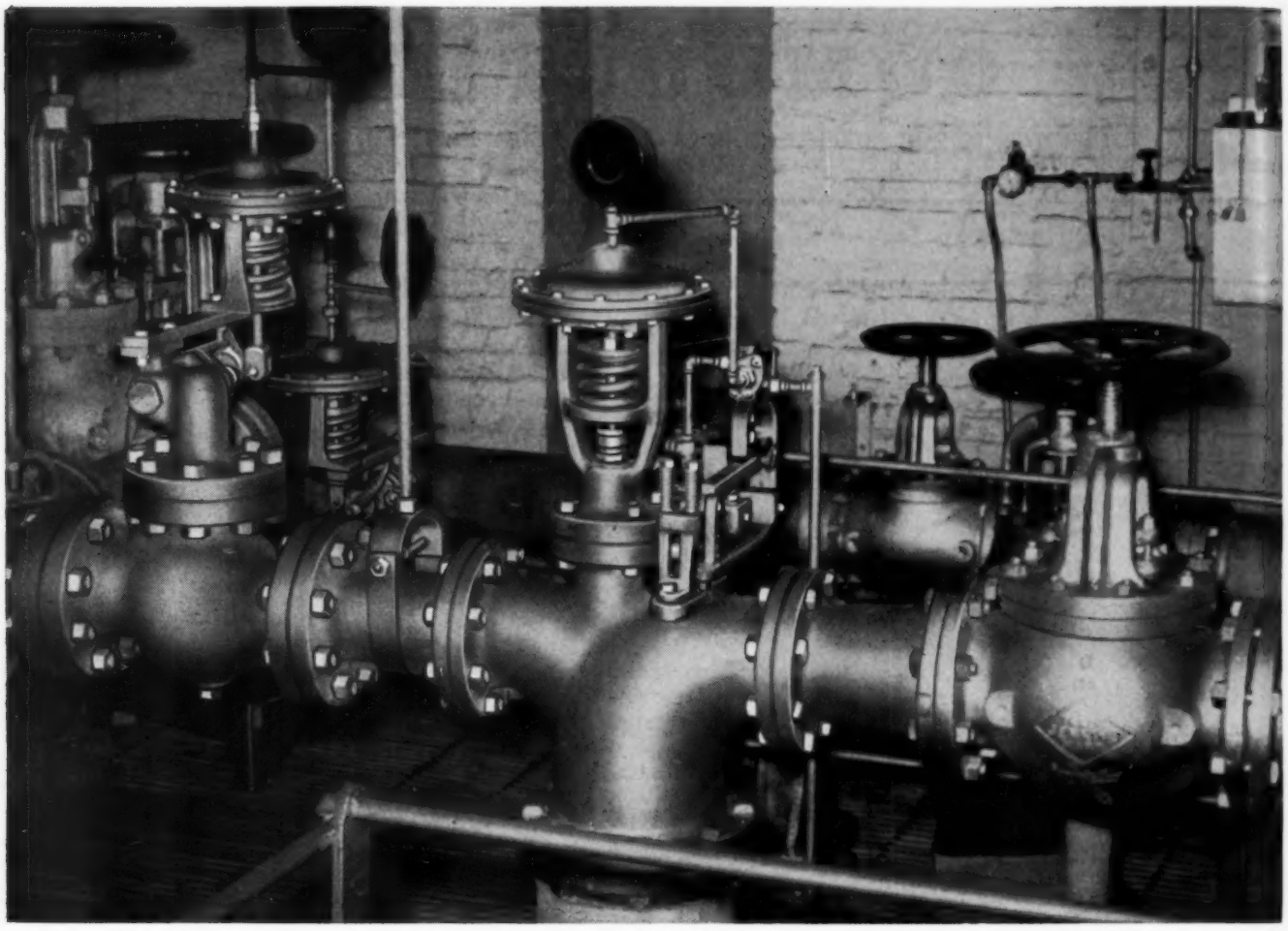
Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING-SUPERHEATER, INC.
Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer

COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $3 in the United States, $3.50 in Canada and Latin America and $4 in other countries. Single copies: 30 cents.
Copyright 1950 by Combustion Publishing Company, Inc.
Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York CCA Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.



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Editorials

Station Costs

One frequently reads or hears mentioned the initial cost of a steam-electric generating station expressed in dollars per kilowatt of capacity. Such figures may be intriguing but they mean little unless the basis of computation is stated, both as to which capacity is selected and what has been included in the initial cost.

For a new plant it is necessary first to know whether the figure applies to gross or net capacity, and then if nominal rating, nameplate rating, maximum continuous capacity or maximum peak capacity is intended. Depending upon which of these is meant, the cost per kilowatt may vary as much as thirty-five per cent, or more.

Some utilities, or perhaps it is more proper to say some engineers, do not include such items as substation equipment, engineering costs, interest during construction and service facilities, or land other than that actually occupied by the power station; thus keeping the apparent cost relatively low.

Again, if referring to an extension to an existing station, when tied in on the steam end, the case becomes still more complicated.

Unless it is definitely known which of the foregoing factors are involved, as the basis for the figures claimed, they will mean very little; and even where they are known the value for comparative purposes with other plants may be small owing to different local conditions. It can be as misleading as an attempt to compare present-day costs with those of stations built before our dollar was devalued.

There actually does not appear to be any accepted yardstick for figuring cost per kilowatt of capacity that is not susceptible of various interpretations.

A Two-Year Respite for Coal

With resumption of coal mining, following the signing of a new contract early this month, the miners can look forward to a period of steady work, at least until depleted stocks have been replenished. After that, because of the many large consumers that converted to oil and gas during the long drawn-out struggle, it is not certain whether the former average work-days per year can be readily achieved. It is certain, however, that a long time will be required for the miners to recoup the loss in wages since last June, which makes the latest apparent victory of Mr. Lewis a hollow one for the miners.

From the operator's standpoint the new two-year contract affords a period of stability in which to concentrate upon production, service and marketing. It will require intensive selling to regain markets lost to competitive fuels, and this will not be an easy task, in view of higher wages and larger welfare fund payments. But it is a challenge which many believe can be met, since coal has been and always will be our basic fuel.

Down-to-Earth Consulting Engineering

At a recent A.S.M.E. Metropolitan Section meeting, one phase of a discussion of the small industrial steam plant centered upon the relationship of the engineering consultant to the industrial plant manager and the plant engineer. While there are those who are accustomed to think of the power plant consultant as a "special breed of engineer", the difference between the intelligent, well-informed plant engineer and the more highly specialized engineering consultant is not as great as is commonly assumed.

Actually, the distinction lies in terms of their respective functions. The plant engineer is charged, among various duties, with the responsibility of steam plant operation and ordinarily does not have sufficient time or adequate personnel to carry out the tedious details involved in the designing and construction of power generation facilities. To perform this function the consulting engineer has a specialized knowledge of plant design that complements the working experience of the plant engineer. Working harmoniously together, the two can produce results that are far superior to the solo efforts of the "know-it-all" engineer of either category.

An indispensable ingredient in this relationship is a feeling of mutual respect. The consulting engineer who can put on a pair of overalls—on occasion—and talk the language of the operators has a definite edge over the high-brow variety. Likewise, the plant engineer who respects the consultant for his specialized knowledge of steam plant design will accomplish more than one who looks upon the consulting engineer with disdain. The real objective is to get the job done, in which both the plant engineer and the consulting engineer have important roles.

More Power for Our Nation's Capital

By L. W. CADWALLADER* and W. J. LANK†

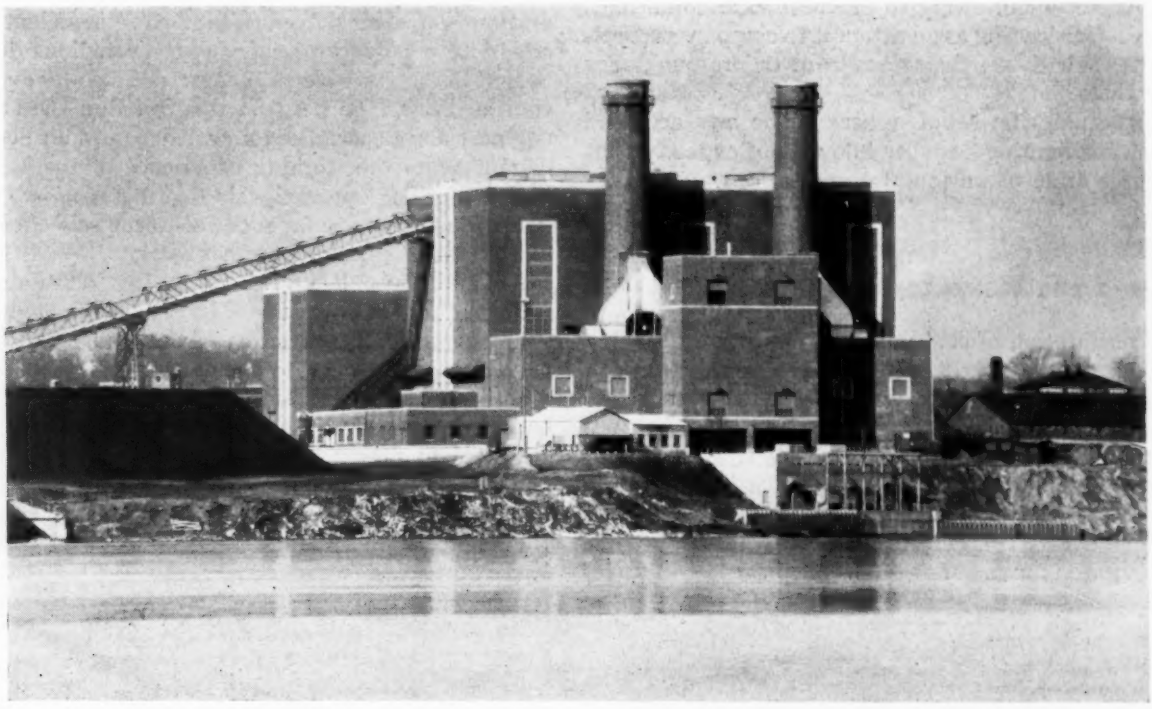
The first 80,000-kw unit of the Potomac River Generating Station of the Potomac Electric Power Company was placed in service on October 16, 1949, and is to be followed by a second unit of similar size scheduled for operation in May of this year. This article discusses some of the problems encountered in the early stages of engineering design, describes the principal equipment, and provides evidence of a station heat rate over a period of 4½ months of operation at throttle conditions of 850 psig, 925 F of 10,842 Btu per kwhr, net output.

TO many, mention of the city of Washington suggests the Nation's capital and the American center of political and administrative activity. However, this is only part of the picture, for Washington is also one of the world's most beautiful cities and over the past decade has undergone a rapid growth in urban population. Quite naturally these two factors, beauty—with its attendant requirement of atmospheric cleanliness—and rapid population increase, have had and will continue to exert considerable influence upon central station design and utility system planning for the capital city.

The Potomac Electric Power Company serves the District of Columbia and surrounding territory, a section characterized primarily by residential, commercial, and government and private office building lighting and service electrical loads. Since industrial power consumption is a relatively small percentage of the total, population increase provides a fairly accurate indication of load growth, providing allowance is made for the increased use of electricity in connection with home appliances, modern lighting and extensive air conditioning installations. This load-growth trend is directly reflected in the steam-plant capacity of the system, which will have jumped from 255,000 kw in 1939 to 665,000 kw by the end of 1950.

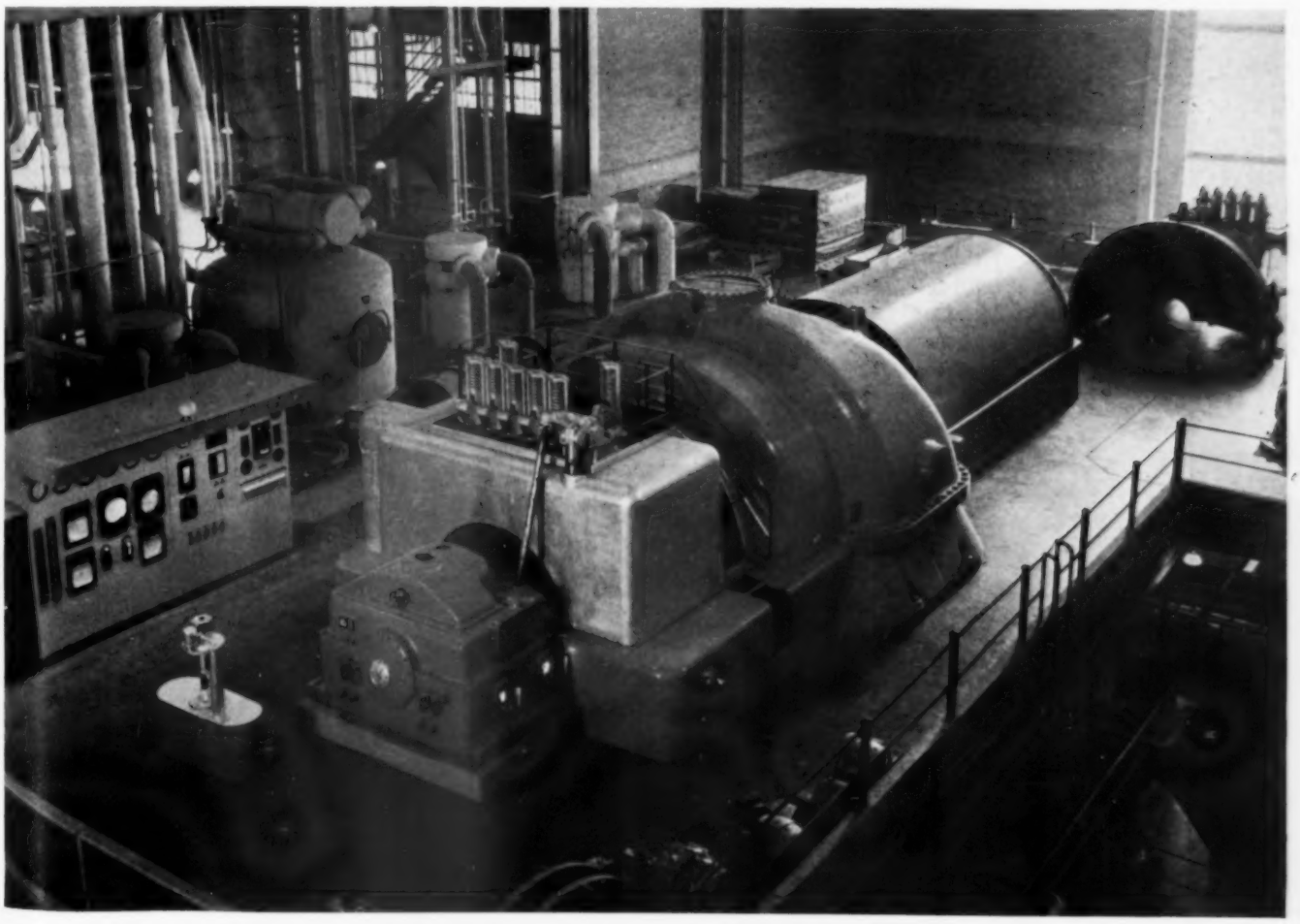
Active planning for the Potomac River Generating Station dates back to 1942, when a site of 23 acres of land was purchased in Alexandria, Va., for the construction of a steam power plant having an ultimate projected capac-

* General Superintendent of Generating Stations, Potomac Electric Power Co.
† Chief Electrical Engineer, Potomac Electric Power Co.

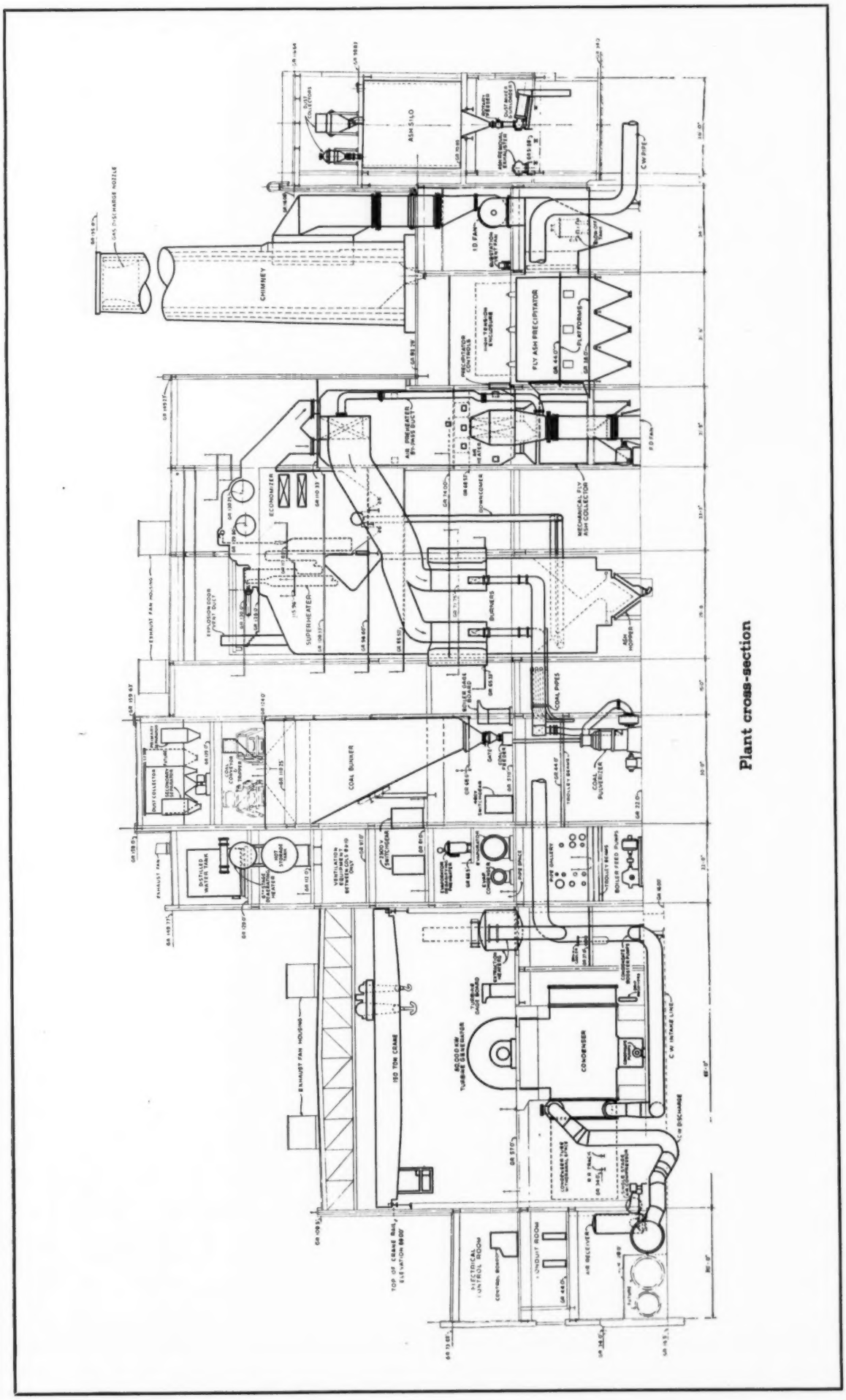


Exterior view of station from Potomac River side; at the time of the photograph, the unit on the left was generating 80,000 kw without perceptible stack discharge

Electrical control board



Turbine room, showing turbine control board and four of the five feedwater heaters



Plant cross-section

ity of 400,000 kw. Located on the Potomac River directly opposite Washington and within view of the Capitol, the first 80,000-kw unit of the new station was placed in commercial service October 16, 1949. A second 80,000-kw unit, duplicating the first, is expected to begin operation in May 1950.

Station design is based on a strict unit system arrangement with a single boiler connected directly to a turbine generator without any interconnections. The only steam-driven auxiliaries in the plant are the auxiliary lubricating oil pumps on the main turbines.

Preliminary Design Problems

There were a number of problems in connection with preliminary design of the station. Because of the location of the plant site with respect to the Washington National Airport, a compromise had to be effected between conflicting requirements of stack height, and subsequently the original height of the stacks was reduced 89 ft. The exterior view of the river side of the station shows that the vertical dimension of the radial brick stacks was limited to a distance above the boiler room roof of about one third the height of the boiler room. It was felt that this was the minimum stack height which would give any assurance of proper and safe dispersion of gases and any remaining solids. At the same time increased velocity of exit gases was provided for by means of a venturi throat or nozzle built within the stack. At full boiler load the velocity of the gases leaving the stacks is approximately 60 miles per hour.

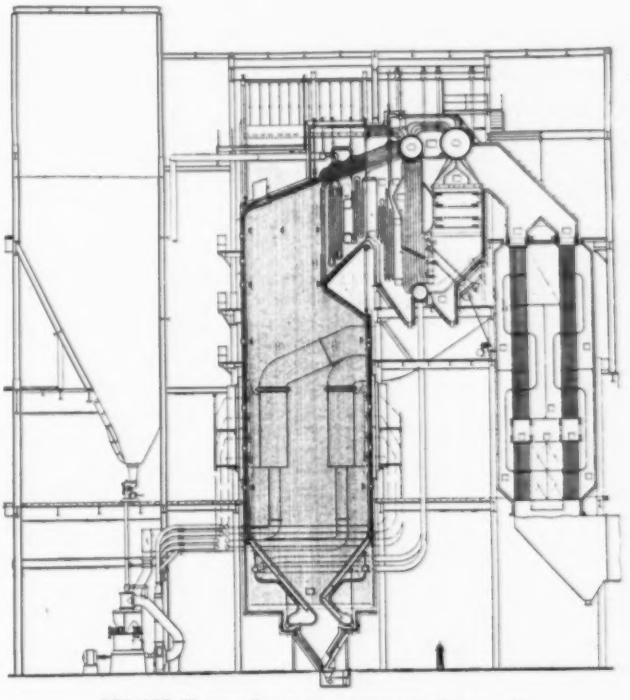
A related consideration was the necessity of harmonizing the external appearance of the station with the general architectural pattern of the area and particularly with that of near-by apartment houses. How this was accomplished effectively but economically is also shown in the exterior views. Red brick trimmed with white limestone and glass block windows make up the outside walls.

Provisions to Minimize Fly Ash and Dust

Every effort was made in the design of this station to eliminate any possible nuisance due to dust and stack emission. It was expected that coal would be the primary fuel and to date only coal has been burned. To reduce stack emission to a minimum, it was decided to install in series both a mechanical fly-ash collector and an electrostatic precipitator three sections deep. These are located between the air heater and the stack, the flue gases passing through the mechanical collector first. The air heater, mechanical collector and electrostatic precipitator are divided into four sections across the width of the steam generating unit, with dampers at the inlet to each section so arranged that one fourth of the precipitator at a time can be rapped in still gas. Design figures indicate a combined dust collector efficiency of better than 99 per cent. Actual performance has been very gratifying although there has not yet been an opportunity to make official tests on the dust collector equipment.

Bituminous coal is delivered to the plant yard which has a capacity of approximately 100 coal cars. The latter are unloaded by a rotary car dumper, emptying into a steel hopper, from which coal is fed onto inclined conveyor belts delivering to a Bradford coal breaker. From this point the coal can be delivered either to the storage area or to the station bunkers. There is one coal bunker per boiler, each bunker having a capacity of 1200 tons. From the bunkers the coal flows through the motor-driven coal feeders which regulate the flow of coal to the bowl mills.

The rotary railroad car dumper is totally enclosed, a rolling steel door being installed at either end to permit the shifting of full cars onto the dumper and the removal of cars after they have been unloaded. Elaborate systems of dust collecting equipment have been provided for the rotary-car-dumper house, Bradford breaker house, coal bunkers in the station, and all intermediate coal conveyor junction points where dust could result from coal transfer. The fine dust thereby collected is conveyed to the coal bunkers by a vacuum system which removes the dust from the collectors and discharges it into either coal bunker.



800,000-lb per hr steam generating unit

To wet the coal as it is placed in storage, a chemical spraying system is provided. It is also planned to spray the surface of the storage pile with heavy fuel oil to prevent dusting.

Steam Generating Unit

The steam generating unit is of the Combustion Engineering three-drum, bent-tube type with water-cooled furnace, pendant-type superheater, economizer, tubular air preheater, vertically adjustable tangential burners and C-E Raymond bowl mills. The furnace is designed for initial operation with pulverized coal, and provision has also been made for possible future use of fuel oil or natural gas. The unit is arranged to burn a wide range of West Virginia and Pennsylvania coals, as follows:

Btu per lb as fired	12,500 to 14,500
Ash fusion temperature	2100 to 2800 F
Ash content, per cent	4.5 to 12
Sulfur, per cent	0.5 to 3.5
Fixed carbon, per cent	53 to 80
Hardgrove grindability	60 to 100

Design pressure for the unit is 1000 psig with operating steam conditions at the superheater outlet of 875 psig, 925 F. As indicated in the accompanying cross-section, the furnace has a dry hopper bottom with shaded ashpit. This design of furnace bottom has resulted in a substantially cooler ashpit than the conventional symmetrical design, and is believed to be the first installation of this type. It is of particular importance in this installation because the furnace bottom ash is removed in a completely dry state by gravity discharge through manually operated gates into a vacuum transport system. This is the same system which empties automatically all of the 33 fly-ash hoppers of each unit.

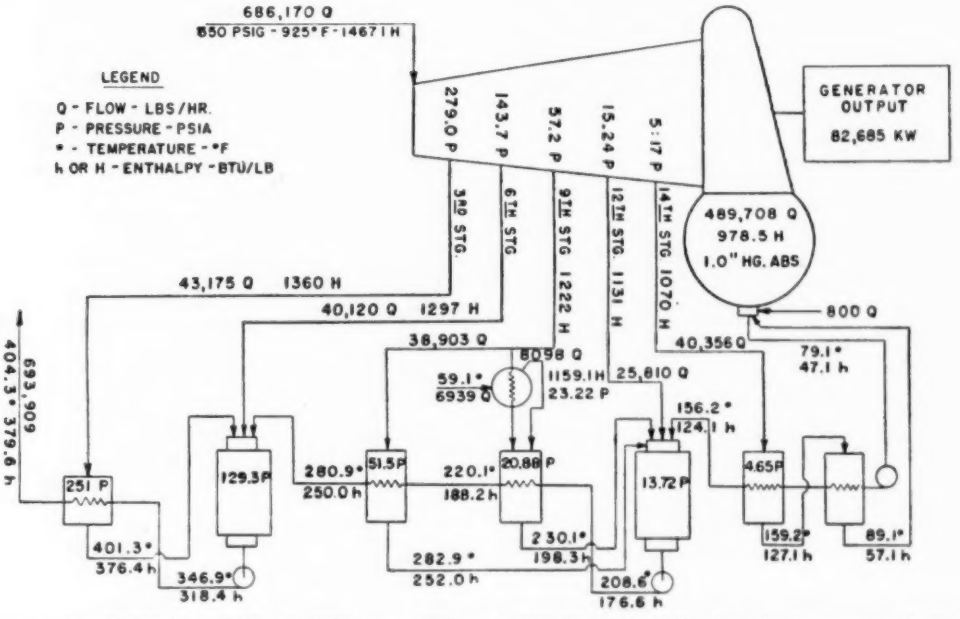
Specifications call for a total steam temperature at superheater outlet of 925 F from 425,000 lb of steam per hour up to the maximum evaporation of 800,000 lb per hr. Operating experience indicates that 925 F can be maintained over a wider load range than was specified. While the design provided for primary steam temperature control by means of tilting burners supplemented by bypass dampers, in operating service under normal conditions the superheater bypass dampers remain closed.

The boiler is provided with four bowl mills with sufficient capacity so that any three will carry full boiler load with good quality coal and four will carry full boiler load with the worst coal specified. There are four levels of coal burners or a total of 16 burners. The secondary air dampers for each level of coal burners are remotely positioned from 5-point selector switches mounted on the boiler gage board and actuating motor drives mounted on burner windboxes. This arrangement of damper control is an innovation and has been quite satisfactory.

The steam generating unit has a maximum continuous rating of 800,000 lb per hr with superheater outlet conditions of 875 psig and 925 F, and feedwater temperature of 420 F entering the economizer. Predicted boiler performance when burning coal and operating under above conditions is 88.9 per cent. The furnace heat release at 800,000 lb per hr output is 16,900 Btu per cu ft per hr and the net heat available for the entire projected radiant surface is 102,000 Btu per sq ft per hr.

Turbine-Generator

The turbine-generator is a General Electric, single-cylinder, 1800-rpm, 80,000-kw nameplate-rated machine with throttle steam conditions of 850 psig, 925 F, steam being extracted at 3rd, 6th, 9th, 12th and 14th stages for feedwater heating. Of the five extraction feedwater heaters, the 14th is a low-pressure closed heater with separate drain cooler, the 12th is a direct-contact heater, the 9th is a low-pressure closed heater, the 6th is a standard tray-type deaerating heater with boiler-feed suction tank, and the 3rd is a high-pressure closed heater. The generator is hydrogen cooled and has a nameplate rating of 80,000 kw at 0.85 power factor and 0.5 psig hydrogen pressure. It is designed for 13,800-volt, 3-phase, 60-cycle service with direct-connected main and pilot exciters.



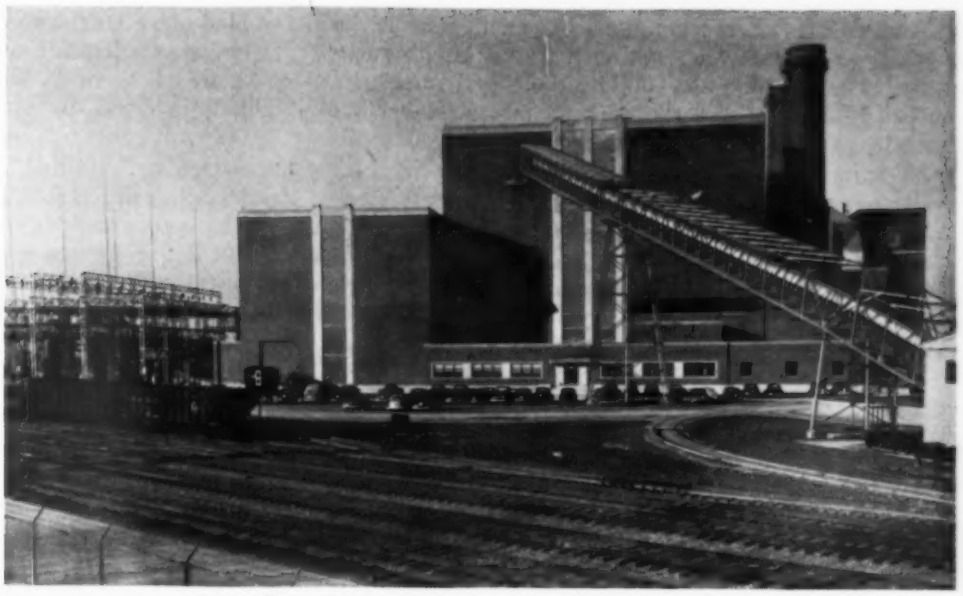
Heat balance diagram for 80,000-kw, 0.85-pf, 1800-rpm, 850-psig, 925-F, 1.0-in. Hg abs., hydrogen-cooled turbine generator

$$\text{Heat rate} = \frac{686{,}170\ (1467.1 - 379.6)}{82{,}685} = 9025 \text{ Btu per kwhr.}$$

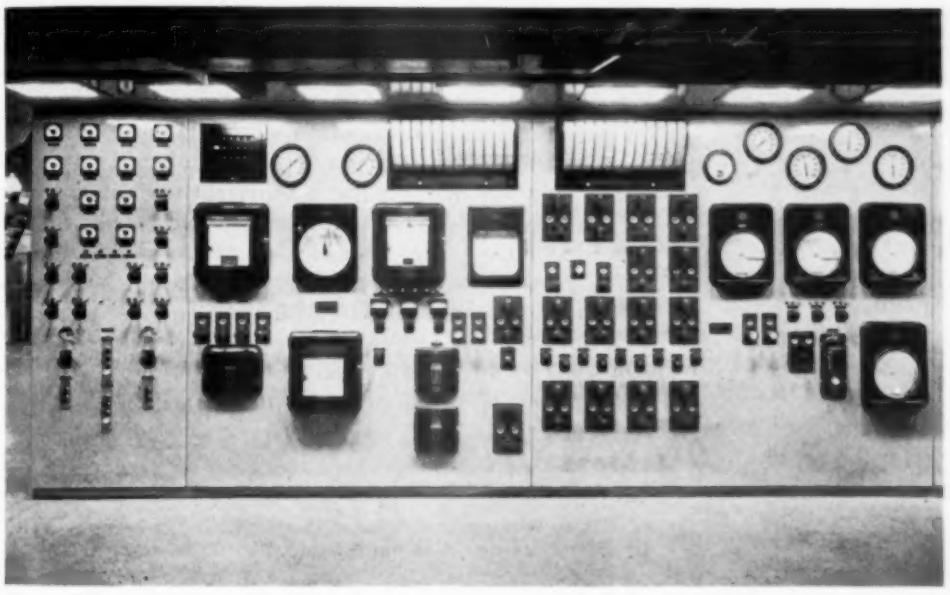
The turbine exhausts into a 75,000 sq-ft, two-pass condenser, containing 12,720 Admiralty metal tubes, No. 18 B.W.G. 26 ft long and $^7/_8$ in. O.D., through which cooling water is pumped at the rate of 66,900 gpm.

An interesting sidelight on the condensers is that the river water circulated through them for the two 80,000-kw turbine-generators will be nearly 200,000,000 gal per day, which is in excess of the normal daily requirements of the entire city of Washington.

Condenser air evacuation is performed by two motor-driven, rotary dry vacuum pumps for each unit. Each pump has a capacity of 540 cfm of air-vapor mixture at one in. Hg abs. pressure.



Coal conveyor and exterior of plant showing the attractive but simple architectural design



Boiler control board

Coal handling and storage facilities

Note enclosed car dumper house with adjoining dust collector shown in right-hand corner.

Condensing water from the river is supplied by two vertical circulating water pumps per unit, each having a rating of 33,450 gpm at a total head of 49 ft. Because of subsoil limitations and the gradient between river bank and the plant, the circulating water pumps were located in a pump house on the river bank and the circulating water pumped through steel pipes to the condensers in the turbine room basement. Inside the station this piping is largely run overhead in order to eliminate foundation difficulties due to subsoil conditions.

Electrical Features

Each of the 80,000-kw, 85 per cent power-factor generators will be directly connected to two 60,000-kva transformers, to step up the energy from 13,800 to 69,000 volts for transmission to the load. Engineering studies showed this to be more economical than tying the generators together at low voltage, and stepping up through transformers tied directly to the 69,000-volt cables. The 13,800-volt generator leads to the transformer terminals are made of the isolated phase construction. These consist of three $20^1/_2$ in. diameter outer aluminum enclosed, dust- and vapor-proofed pipes. Inside of each pipe a 6-in. copper tube is used as a conductor which is securely braced at each 90-deg angle and supported and insulated by porcelain insulators at five to eight feet intervals to withstand the shock of short circuit.

Main step-up transformers are equipped with fans arranged to blow air on the radiators to permit carrying their rated load without excessive temperature rise. The main 60,000-kva step-up transformers are connected on the 69,000-volt side to the main station buses through pneumatically operated oil circuit-breakers which are capable of opening short circuits of 2,500,000 kva. The transformers, oil circuit-breakers and associated high voltage equipment are located in a switch yard adjacent to the turbine room. Ultimate layout of the station provides for five sections of 69,000-volt bus, each fed by two 60,000-kva transformers from different generators, and each feeding two to three 45,000-kva cables. These cables are connected to the bus by oil circuit-breakers similar to those connecting the transformers. In case of a short circuit, the proper breakers to disconnect the faulty equipment are opened automatically by relays. Normally, the bus sections will be tied together only through the generator transformers, although they can be tied directly together by means of oil circuit-breakers when a generator is shut down for any reason. The purpose of this bus arrangement is to "cushion" and control the large amount of generated power and to prevent excessive short circuit currents at the generating station.

Underground Transmission Lines

In spite of the heavy cost involved, it was necessary that all lines transmitting the energy away from the station be underground. Much of the territory between the station and the city of Washington has been carefully landscaped to provide scenic approaches to the city, and the appearance of overhead lines would have been objectionable.

Studies showed that three 600 MCM-conductor, 69,000-volt cables in conduit would be more economical than higher-voltage, single-conductor cables, or cables pulled in pipe. This was the highest voltage three conductor cable available and two such cables furnish sufficient capacity to load one 80,000-kw generator. Conductors and insulation are enclosed in a lead sheath and a nitrogen gas pressure of 35 to 45 lb is maintained inside the cable. This is believed to be the first installation of gas-filled 69,000-volt cable. This so-called "gas-filled" cable was preferred to "oil-filled" cable because of lower installation and maintenance costs. The outside of the lead sheath is reinforced by bronze tapes and the whole cable enclosed in a neoprene jacket for protection against mechanical and chemical damage and electrolysis.

Due to unstable earth conditions over a part of the route between the generating station and Washington National Airport, the cables in this section are of the submarine type covered with metallic armor and no conduit is used. This permits movement of the cables, without damage, when the earth support moves. Many of the features described above are novel, but all are based upon sound engineering and the lines should give high-quality service.

Station Performance and Cost

A comparison of the theoretical heat balance for the station and actual operating results for the period extending from October 16, 1949, to February 28, 1950, discloses several noteworthy accomplishments. It will be noted that the theoretical turbine heat rate is 9025 Btu per kwhr, which is equivalent to a calculated station heat rate of 10,750 Btu per kwhr net sendout, based on a boiler efficiency of 89 per cent and an average auxiliary power consumption of 5.6 per cent of gross generation. For the month of December 1949 the net station heat rate was 10,771 Btu/kwhr, and over the four and one-half month period it was 10,842 Btu/kwhr.

The following tabulation provides more details of station performance over this extended period of four and one half months:

Total kwhr gross generation	227,136,000
Total kwhr station use	13,034,000
Total kwhr net output	214,102,000
Station service, per cent of gross	5.74
Steam temperature, F, weighted average	921
Steam pressure, psig, weighted average	875
Feedwater temperature, F, weighted average	394
Makeup, per cent of total feedwater	0.315
Condenser back pressure, in. Hg, weighted average	0.75
Circulating water temperature, F, weighted average	47
Average load, per cent	90.6
Capacity factor, per cent	87.0
Station water rate, lb per kwhr (gross)	8.27
Boiler efficiency, per cent (net)	88.6
Boiler use factor, per cent	96.0
Lbs coal per kwhr, net	0.785
Btu per lb, coal, as fired	13,808
Btu per kwhr, gross	10,220
Btu per kwhr, net	10,842
Thermal efficiency, per cent	31.48

Based on a nameplate generator rating of 160,000 kw and including cost of site and everything constructed on it except outgoing feeders and the external distribution system, the cost of the Potomac River Generating Station will approximate $155 per kw. Considering the general advance in construction, equipment and labor costs, this is well in line with estimates prepared during preliminary planning for the station.

Consulting engineers and constructors for the station are the Stone & Webster Engineering Corporation, whose engineers worked in close cooperation with the operating and engineering departments of the Potomac Electric Power Company.

Notes on High-Temperature Superheaters

THE following are excerpts briefed from a talk by W. S. Patterson[1] before the Metropolitan Section A.S.M.E., on February 1, in which some of the design factors of a steam generating unit that are directly related to steam temperature are discussed:

Use of superheated steam at higher and higher temperature to improve power station efficiency has kept pace with the ability of the metallurgical art to produce the metals with which to construct superheaters and turbines. While increase in steam temperature has been gradual, there have been periods when available materials prevented designers from taking advantage of the corresponding gain resulting from higher inlet turbine pressure; because, within certain limits, steam temperature and steam pressure must increase together on straight-through condensing units to prevent excessive moisture in the last stages of the turbine. During the early 1920's the desire for higher station efficiency and the limit of 750 F imposed by materials and construction techniques then available led to the use of reheat. This resulted in higher efficiency without the high moisture content in the turbine exhaust and, at the same time, permitted use of higher initial pressure.

Steam Temperature Dominates Design

Specified steam temperature leaving the superheater influences the type of boiler selected in that it affects the size and location of the superheater. With steam temperatures exceeding 900 F the superheater becomes very large and the corresponding gas temperature drop great. Therefore, in order to have an economical temperature difference between gas and steam at the cold end, the gas inlet of the superheater must be located in a zone of high gas temperature. This limits the amount of convection boiler surface that can be employed as a screen between furnace and superheater.

Some large boilers are now operating with steam temperatures of 1000 F and 1050 F and some are using interstage reheating to 1000 F. In such units the heat absorption of the superheater may exceed 40 per cent of the total absorption by all pressure parts including furnace, boiler and economizer.

When the gas temperature entering the superheater must be close to the fusion temperature of the ash, it is customary to divide the superheater surface into two or more sections with wide tube spacing in the gas inlet section and much closer spacing in the gas outlet section.

With counterflow, gas temperature drop for a given steam temperature rise is related principally to the weight of gas per pound of steam which, in turn, is related to such variables as operating pressure, feedwater temperature, excess air and overall efficiency.

For a given heat absorption, the required superheater surface depends on the heat transfer rate and the mean temperature difference. The first of these two variables is related to tube diameter, tube spacing and gas velocity; whereas the second is related to the degree of counterflow achieved and to the cold-end temperature difference.

With a given design, if the specified inlet gas temperature be lowered, a lower gas outlet temperature will result, with a corresponding lower mean temperature difference; hence more superheater surface would be required. Also, more superheating surface must be employed if a higher steam temperature is desired without increasing the entering gas temperature.

It is obvious that at the cold end of a superheater operating with a low cold-end temperature difference, the use of a counterflow arrangement is more necessary than at the gas inlet end where the temperature difference is so great that parallel flow can often be employed to advantage in keeping down the cost of the high-temperature section. This places the high-temperature alloy in a lower temperature zone.

It is interesting to note that a reheat installation superheating and reheating to 1050 F and 1000 F, respectively, is about the equivalent in superheater heat absorption and furnace design requirements to a non-reheat boiler superheating to nearly 1300 F.

Superheat Control

With fixed burners in a radiant furnace the exit gas temperature increases with increase in load, due to the fact that at higher rates of heat input the fraction of the heat absorbed by the furnace walls decreases. Increased load also results in decreased heat absorption efficiency in a convection superheater because the heat transfer rate varies directly as the gas mass velocity raised to a power less than 1. Therefore, even though the required superheater gas temperature drop may be nearly constant over the control range, it will require a greater mean temperature difference to accomplish the required heat transfer as the load and gas velocity increases, thereby increasing the necessary gas inlet temperature to the superheater. However, this increase in required gas temperature with load increase is much less than the increase in actual furnace exit gas temperature, when the burners are fixed. Hence control equipment becomes necessary, its type influencing design of the whole unit.

Certain control methods make it necessary to select the superheater large enough to accommodate a reduced load control point, with the precaution that at maximum load the uncontrolled gas temperature leaving the furnace shall not exceed the ash-fusion temperature. Thus a limitation is placed on the designer, inasmuch as the required inlet gas temperature, even at the design point, may approach the ash-fusion temperature of some coals.

Use of spray desuperheaters for full temperature control involves the introduction of solids, dissolved in the spray water, directly into the superheated steam, the evaporation of steam from the spray water, and a corresponding reduction in water flow through the economizer.

The most logical means of superheat control, which permits selection of the superheater for maximum load, is to control the temperature of the gases leaving the furnace. This is readily accomplished with tilting burners, which, in effect, give an adjustable furnace.

[1] Executive Assistant, Engineering Department, Combustion Engineering-Superheater, Inc.

PRIMING OR FOAMING?

Carryover is a tough problem that you can't argue, or guess, out of existence. It can cause serious mechanical, operating and processing difficulties, ranging from damage to process materials to deposits on high pressure turbine blades. To know the cure, you *must* first know the cause. The chief causes of carryover are priming and foaming.

Priming, the *mechanical* entrainment of boiler water in steam, is caused by "belching" or surging. Its correction usually involves *mechanical* considerations, such as operating and design modification.

Foaming, the entrainment of boiler water in steam, is caused by build-up of foam. It results from high alkalinity, high dissolved and suspended solids, oil contamination, etc. Correction of foaming usually involves *chemical* considerations, such as proper control, anti-foam treatments, etc.

The Drew System of Water Treatment eliminates guesswork! It starts with proper diagnosis. It includes recommendations for corrective treatment and other preventive measures, such as modification of operating cycles and redesign of equipment, if required. It is specialized service applied to your individual boiler problem.

Don't gamble with guesses! Consult the Drew Engineer or write for further information on carryover and other water problems.

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DREW PRODUCTS

New Water Treating System Produces CO_2-Free Steam—II

By LEO F. COLLINS* and ERNEST E. DUBRY†

Part I, published in the February issue, described a zeolite-acid degasification system designed by Detroit Edison engineers and installed in the Willis Avenue Heating Plant of that company. It treats the feedwater to rid it of CO_2 held in chemical bondage as carbonate salts; also that existing in the form of gas. The present article relates operating experiences and the results achieved.

BECAUSE of the automatic features built into the system the manipulations of shift operators are limited to the following:

1. Regeneration of the zeolite softeners. (During *extreme* peak load periods, which always occur during the day, a man from the maintenance crew is assigned to assist in this work.)
2. Selection of the stipulated combination of manifold lines to insure proper "ranging" of the acid proportioners. (Normally this necessitates the manipulation of three valves during a 24-hr period.)
3. Adjustment of the acid orifices to compensate for changes in the alkalinity of the soft water. (Seldom are more than three such adjustments required in a period of 24 hr.)
4. Change the stroke of the caustic pump. (Two such adjustments per shift are normal.)
5. Adjustment of the control valves on the continuous blowdown lines. (Normally three changes per value per shift suffice.)
6. Check the alkalinity of the city water, the heater influent and effluent at least once each shift.

Zeolite Softeners

The on-off cycles of these units are dictated by floats located in the soft-water reservoirs. These floats are electrically connected to a motor-operated valve in the influent line, and also to the remote control panel located at the engineer's desk. By means of the remote controls any or all softeners can be cut out of service or reconnected to the floats and thus returned to service.

When the zeolite softeners were first assembled the well screens were unwittingly fabricated, in part, of 60–40 brass rather than the 85–15 brass specified. After about four months of operation an "epidemic" of well screen failures occurred. The specified alloy was then substituted and no troubles of this nature have since been experienced.

Through an error in specifications these units were initially supplied with greensand that had been intentionally processed to yield large porous grains of high exchange capacity. In operation this zeolite rapidly disintegrated. This situation was rectified, by the original vendor, by substituting greensand processed to provide smaller and harder grains with but a negligible sacrifice in exchange capacity.

Thereafter a regeneration technique was adopted wherein backwashing was eliminated, prior to introduction of the brine. This reduced the total wash water used for regeneration to about 3 per cent of the amount of water softened between regeneration. However, it resulted in the accumulation of "fines" to such an extent that some were carried into the reservoirs and heater. Accordingly, the technique was abandoned.

Acid Proportioning

One acid supply pump, which is always in operation can supply far more dilute acid than will be required by all three acid proportioners under peak load conditions.

TABLE 4—CRITERIA FOR OPERATION OF MANIFOLD

This table shows the proper heater feed lines and combinations thereof that should be used for various water flows. When these combinations are used the mercury columns always show a pressure differential between 1.5 and 14 in. of mercury. Within these limits the acid proportioners yield accurate results.

Water from Heater, 1000 Lb per Hour		Heater Feed Lines to Be Used; Line Designation*
Min	Max	
20	65	A
57	180	B
77	235	B and A
155	470	C
175	535	C and A
210	650	C and B
230	715	C, B and A

* Size of orifice: A = 1.435 in., B = 2.456 in., C = 3.954 in.

The excess returns by gravity to the dilute acid reservoirs. Thus, an adequate supply of thoroughly mixed acid is always available to all proportioners.

Since an individual acid proportioner is attached to each of the three pipes of the water manifold in the heater influent line, the appropriate proportioner is automatically put into, or cut out of, service when the valve, which controls the flow of water through the corresponding pipe of the manifold, is opened or closed.

A chart similar to that shown in Table 4 is used to

* Chemical Engineer, The Detroit Edison Company.
† Superintendent of Central Heating, The Detroit Edison Company.

determine which pipe or combination of pipes, in the manifold, should be in service for various plant outputs.

The circles in Fig. 15 indicate performance of the acid proportioning equipment.

The first acid supply pumps installed were of the horizontal type (with an overhanging bearing) operated at about 3500 rpm against a 112 ft head. Failure of the ball bearings occurred at regular intervals of about six weeks; nor was a suitable packing discovered. However, when the same pumps were operated (as acid-injection pumps) at about 1500 rpm, neither bearing nor packing troubles were encountered.

Because of the bearing and packing troubles, and the need for injection pumps, these horizontal pumps were moved to a new location (to serve as injection pumps) and vertical pumps, that require no packing or mechanical seal, were provided to supply acid to the constant-level reservoirs. In the latter type of pump all parts contacting the acid are fabricated from the copper-nickel alloy commonly known as IR 55. Two years of operation of these units indicates some etching of the metal by the acid, but otherwise generally satisfactory service has been obtained. All acid pumps were supplied by the LaBour Pump Company.

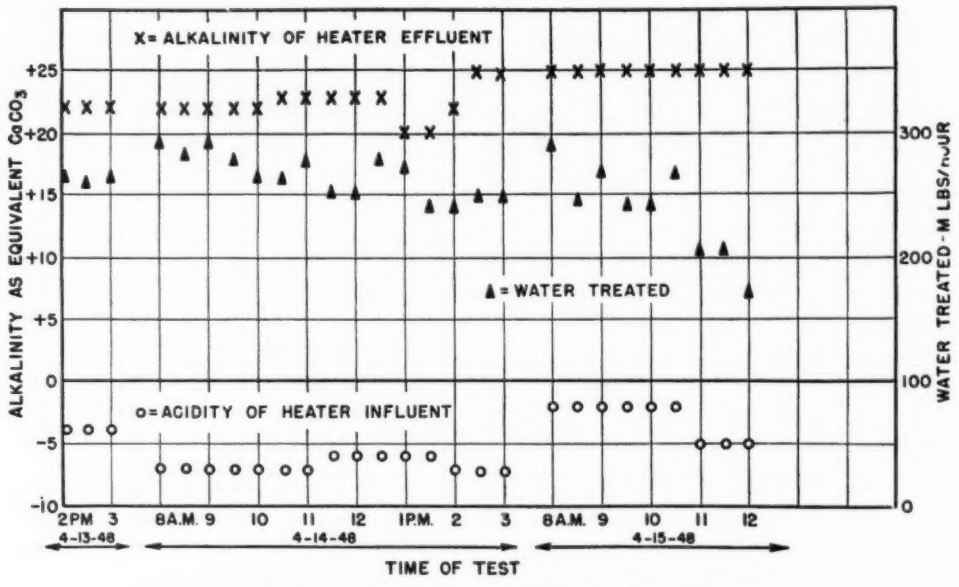

Fig. 15—Data from operating records showing performance of acid and caustic proportioners

Gas Removal

The data in Table 5 represent the performance of the feedwater heater.

TABLE 5—DATA ATTESTING PERFORMANCE OF DEGASIFYING HEATER

	Dissolved Oxygen Min	Dissolved Oxygen Max	Carbon Dioxide Min	Carbon Dioxide Max
Water to heater (acidulated)	8.0*	14.0*	50	90†
Water to atomizing valve	0.10	0.20	1.0	5.0
Water in storage space	.0003	.0050	Below 0.10	

* Varies with atmospheric temperature.
† Seasonal variations.
All values are parts per million.

The very low values for dissolved oxygen were determined by the referee method specified by A.S.T.M. (21).[1] Manifestly, the very low values cited for CO_2 could not be measured by either of the "direct" methods of measurement known (22) (23). The procedures utilized to obtain the figures cited, are described later in the paragraphs entitled "Steam Purity."

TABLE 6—DATA SHOWING QUALITY OF CONDENSATE FORMED IN THE AFTER-CONDENSER

Dissolved oxygen, ppm	4 to 6*
Carbon dioxide, ppm	90 to 425
pH value	5.0 to 5.5
Temperature, deg F	120 to 150
Corrosivity† to	
Common steel	171
Cast iron	145
Yellow brass	33
Copper	19
Stainless steel (Type 316)	0

* Large amounts of undissolved air are also entrained.
† Rate at which the metals shown were corroded. Units used are average penetration in inches per year × 1000. Experience indicates that when common steel exhibits a corrosion rate over 20 the corroding medium is decidedly aggressive.

In the initial design of the system it was judged that the corrosivity of the drips from the after-condenser would be very high; that as a result such condensate should be directed to waste, via the blowdown tank, rather than provide special metals for a condensate-recovery system that would satisfactorily return the condensate to the top of the feedwater heater.

The soundness of this conclusion has since been confirmed. Black steel pipe, used temporarily to convey the condensate to the blowdown tank, failed repeatedly in about six weeks. Measurements made with N.D.H.A. corrosion testers (24), using five different metals, gave the results shown in Table 6. The high corrosivity of the condensate is further attested by the analytical data also shown in Table 6.

[1] Figures in parentheses refer to references at end of this article.

Caustic Feed

The points noted by X in Fig. 15 show the performance of the caustic-proportioning equipment. The pumps are flushed with hot (boiler feed) water for about 15 min. once each week. Virtually no operating troubles have been encountered with these pumps.

One near fatal accident occurred in preparing the caustic solution. This resulted from a blowback of the hot caustic solution through the filling hopper when the dry caustic was being introduced. An entirely adequate explanation of this occurrence has not yet been obtained. It is believed to have resulted from the use of too hot (212 F) water. Subsequent to this accident means were provided to cool the water to about 150 F and an explosion relief was installed. Since these expedients were provided no troubles have been encountered in preparing the 10 per cent caustic solution.

Normally a recording pH meter is used as the guide for adjusting the stroke of the caustic proportioning pumps. As a check, a sample of caustic-treated water is titrated once each shift and a chart is consulted which defines (approximately) the setting of the pump (micrometer dial) for the prevailing load.

Analyses of the caustic solution have shown that it contains up to 1000 ppm of CO_2 (combined as Na_2CO_3). Since the caustic solution is pumped directly into the water storage space of the heater the CO_2 so introduced finds its way into the boilers. It will be shown later that this accounts for virtually all of the CO_2 found in the steam leaving the plant.

Phosphate Feed

When the system was first put into operation phosphoric acid was mixed with the sulfuric acid. Then, when the degassed water was subsequently alkalized by addition of the caustic, the small amount of calcium in the zeolite-softened water was precipitated and formed a feed-line scale. In an effort to delay this precipitation small amounts of oxyganic dispersive agents (lignin bodies) were employed upon an experimental basis. Although this expedient minimized the amount of scale formed, a layer approximately 0.05 inch thick was found after one year of operation.

To avoid repetition of such an occurrence the use of phosphoric acid was discontinued. Instead tri-sodium orthophosphate is introduced periodically into each operating boiler. For this purpose the standby caustic pump is employed.

Boiler Water Conditions

The photograph, Fig. 16, when compared with Fig. 5 (in Part 1) indicates that sludge no longer constitutes a problem.

The data represented by Fig. 17 indicate the boiler water concentrations that persist. Operation to date shows that such conditions keep the evaporative surfaces satisfactorily free of scale and corrosion at all steaming rates up to the maximum obtainable with the available firing equipment.

Steam Purity

Analyses of the plant steam, using the techniques described by Ulmer (25) disclose a total solids content within the range 0.14 to 0.15 ppm.

When the steam is condensed in a preoxidized copper coil under conditions believed to insure solution of all entrained substances, the pH value of the resulting solution varies within the limits 6.1 to 6.3 at 40 C. and the conductivity varies within the ranges 0.80 to 0.95 micromhos at approximately 40 C.

A group of 17 consecutive readings taken at 10-min intervals gave the following averages: pH 6.18, conductivity 0.914 at an average temperature of 39.72 C; a second group of 19 readings (some days later) also taken at 10-min intervals showed averages of pH 6.25 and conductivity 0.920 micromhos at an average temperature of 39.41 C. During the time the latter data were being collected steam was also condensed in a degasifying

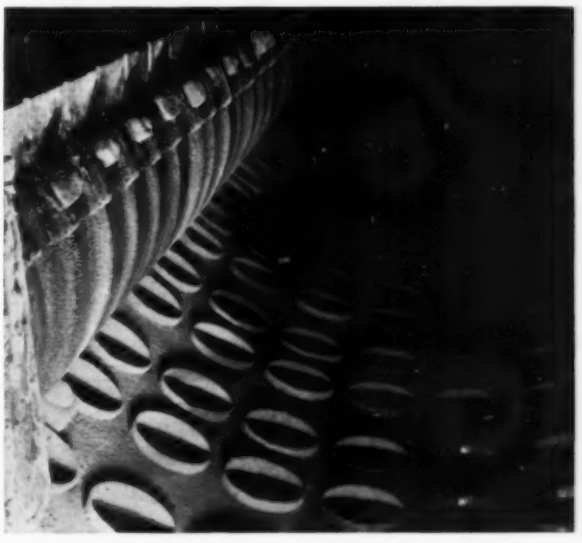

Fig. 16—Scale and sludge beneath water trough were slight after 12 months operation with new system

condenser of the type described by Rummel (29). An average of 14 such readings gave pH 8.00, and conductivity 0.77 at an average temperature of 39.0 C.

In all cases the steam supplied to the sampling condensers was at a pressure close to 125 psig, and was caused to pass through a large steam separator before entering the condensers, the purpose of the separator being to eliminate, in so far as possible, small amounts of boiler water.

There are sound reasons for believing that in a 125-psig line operating at high velocities saturated steam can entrain small amounts of CO_2 and NaOH, without the two reacting. It seems equally as sure that when such a steam is condensed in a degasifying type condenser virtually all of the CO_2 will be purged. For these reasons it is felt that the difference between the conductivity of the steam condensate produced in the non-degasifying condenser and that produced in the degasifying condenser provides a reasonably accurate index of the CO_2 content of the steam. If these are valid deductions, and if the curves in Fig. 18 are reliable, then it is indicated that the steam contains approximately 0.2 ppm of CO_2.

The validity of the figure cited for CO_2 is further attested by the following: A pH value of 8.0 in the degasified condensate is proof of the fact that a very small

TABLE 7—DATA INDICATING CHEMICAL PURITY OF STEAM GENERATED

	Comparative Power Plants*				
	A	B	C	D	Willis Ave.†
Conductivity, micromhos at 25 deg C	1.50–2.40	0.700–1.60	0.300–0.60	0.400–0.600	0.800 –0.950
pH Value at 25 deg C	8.0 –9.0	8.0 –8.8	7.7 –8.5	6.4 –8.4	6.2 –6.4
Dissolved oxygen, ppm	0.01–0.03	0.002–0.02	0.003–0.02	0.002–0.012	0.0003–0.005
Total solids	0.25–0.40	0.25 –0.40	0.25 –0.40	0.25 –0.400	0.15 –0.20

* Virtually all boiler feedwater is condensate.
† Total boiler input is treated water.

amount of alkali is present in the solution. Presumably this alkali is caustic soda inasmuch as it is the predominant alkali in the boiler water. Calculations[2] show that if 0.0635 ppm of NaOH be added to otherwise pure water the pH of the resulting solution will be close to that found in the degasified condensate. Further, if such a quantity of NaOH be present in the condensate and the 1000 ppm. The amount of 10 per cent caustic solution added is about 300 lb per million pounds of water treated. In view of these figures, it is clear that the CO_2 content of the caustic soda solution, which is added to the water after the degasification section of the feedwater heater has been traversed, may contribute up to 0.3 ppm of CO_2 to the plant steam. Thus, it is a certainty that the

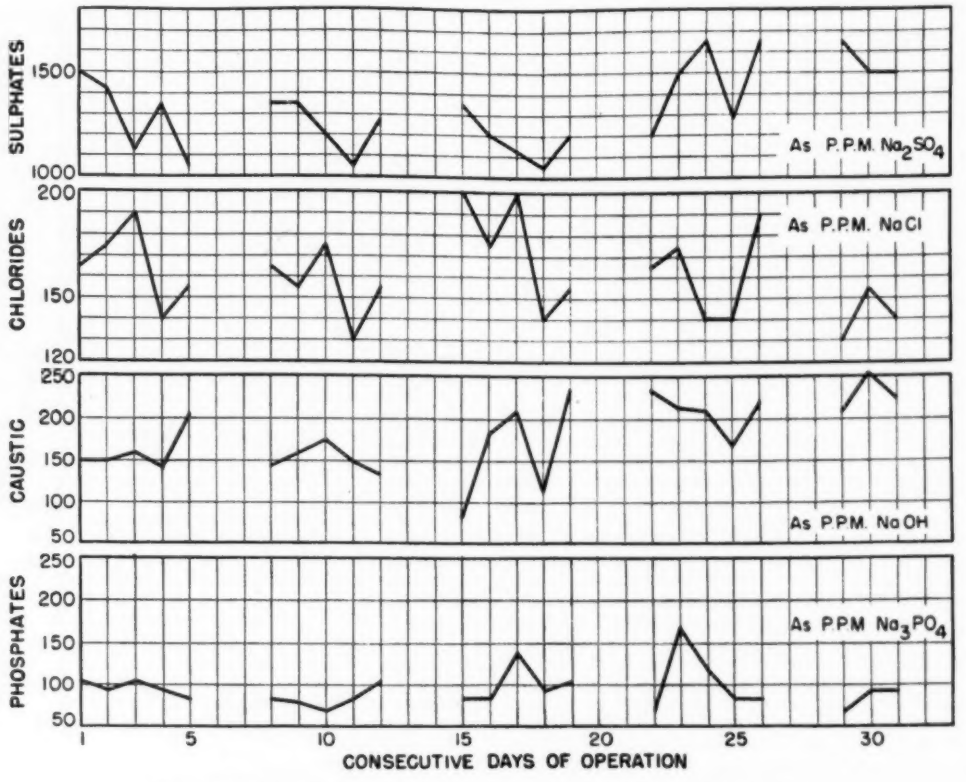

Fig. 17—Data indicating chemical quality of water in boilers, as taken from operating records

latter evaporated to dryness, following the Ulmer techniques, virtually all would be converted to the equivalent $NaHCO_3$. Thus, in weighing, 0.13 mg of residue would be found for each liter of condensate evaporated. This figure checks well with the 0.14 to 0.15 ppm of solids found.

If it be conceded that 0.0635 ppm of NaOH and 0.20 ppm of CO_2 are present in the plant steam and if the latter be condensed in such a manner as to put both into solution, it can also be shown, by calculations, that the resulting solution will have a pH close to 6.2. The latter value, ±0.1 pH, is consistently registered by the recording pH meter for solution temperatures of 40 C.

The total CO_2 content of the caustic soda solution pumped into the water space of the heater varies up to heater reduces the CO_2 content of the water to well below 0.1 ppm.

The data in Table 7 reflect the chemical quality of the steam produced at the Willis Avenue plant and of the steam produced in each of the company's four power generating stations wherein virtually no treated makeup water is used. From this comparison it is indicated that a method has been developed whereby steam can be produced, from carbonate bearing feedwater alone, that is comparable in quality to that produced where only condensate is employed as boiler feed.

Experiments have indicated that the corrosivity of a CO_2 ladened steam subscribes to the equation (3).

$$P = 0.46\ (0.1\ RC)\ 0.52$$

If this equation is valid the maximum potential corrosivity of the steam produced by the plant in ques-

[2] Based upon the relation $pH = \text{Log}\ \frac{\alpha OH\ ppm}{17} + 11$, and assuming the activity coefficient (α) = 1.

tion before and after the installation of the present water-treating system is as indicated in Fig. 19.

Instrument Maintenance

The maintenance required by instruments common to steam boiler plants is too well known by engineers to warrant discussion here. Thus, only maintenance of the acid proportioning equipment, the pH meter, and the recording conductivity meters will be discussed.

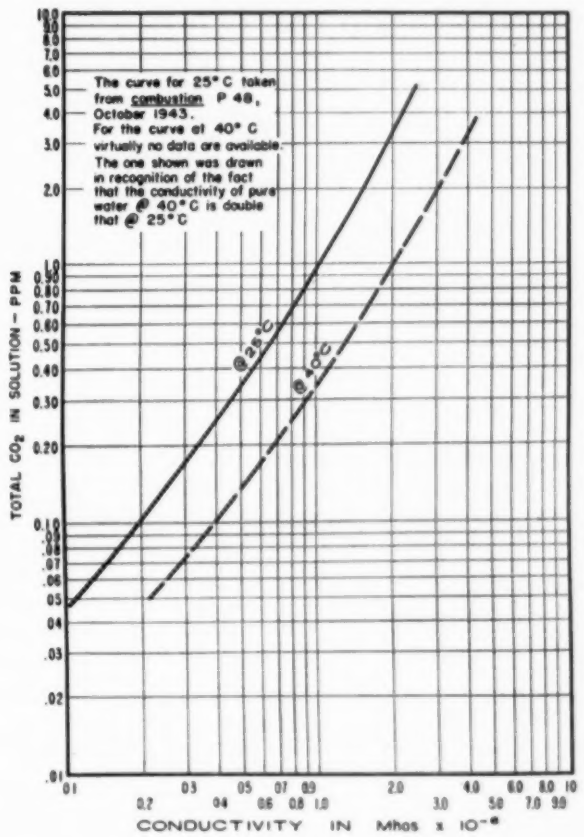
The curve for 25° C taken from combustion P 48, October 1943.
For the curve at 40° C virtually no data are available. The one shown was drawn in recognition of the fact that the conductivity of pure water @ 40° C is double that @ 25° C
@ 25°C
@ 40°C
TOTAL CO_2 IN SOLUTION - PPM
CONDUCTIVITY IN Mhos x 10^{-6}

Fig. 18—The relation between conductivity and CO_2 content of solution when CO_2 is dissolved in otherwise pure water.

Experience has shown that the screens in the acid constant level tanks should be removed about once monthly and brushed. Once weekly each of the acid orifices is flushed to insure the absence of accumulated debris.

Each of the three points of the pH meter is checked twice weekly against a portable pH meter, equipped with a glass electrode and flow-type cell. Usually such checks show that only minor adjustments of the asymmetry potentials are required. Every other month the reference electrode, in each of the three cells, is replaced with a "repacked" unit, and the glass electrode is washed with strong hydrochloric acid.

The recorders of both the pH and conductivity meters are cleaned and oiled about once each week.

The conductivity cells are flushed regularly once weekly to insure that no debris (mostly sludge) has plugged the orifice.

Increment Operating Costs

No additional men were added to the plant pay roll as a result of installing the water-treating system. It is a certainty that if no water treatment were employed, peak plant output requirements would necessitate the addition of shift operators, and considerably more man-hours would be required for plant maintenance. Thus, even though the labor, devoted to the operation and maintenance of the water-treating equipment, constitutes a part of the operating costs of water treatment it is felt that omitting such charges will not distort the figures unfairly. Accordingly, the operating costs computed are for chemicals, water, heat, and chemicals lost in processing. Manifestly, all vary directly as the amount of water treated. The figures are recorded in Table 8.

TABLE 8—OPERATING COSTS—WATER AND TREATMENT

	Cents per 1000 Lb of Steam Produced
Water at 1.0 cent per 1000 lb	1.000
Treatment	
Salt, 0.33 lb at 0.4 cent per lb	0.132
H_2SO_4, 0.094 lb at 2.3 cents per lb (average)	0.216
$Na_3PO_4 \times 12\ H_2O$, 0.017 lb at 4.4 cents per lb	0.075
NaOH, 0.024 lb at 4.25 cents per lb	0.102
Wash water, 67 lb at 0.001 cent per lb (regeneration)	0.067
Blowoff, 70 lb at 0.0024 cent per lb	0.140
Total	1.732

When the original water-treating system was in operation experience proved that, to avoid troubles attendant upon scale and sludge formations, no boiler could be operated for prolonged periods at rates in excess of seven pounds of steam per square foot of evaporating surface per hour. As a result, the total available continuous boiler output was 583,000 lb per hr.

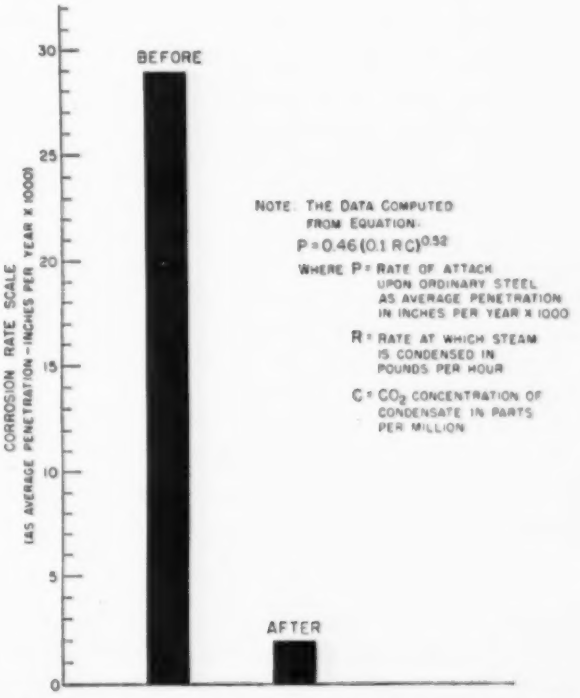
BEFORE
AFTER
CORROSION RATE SCALE
(AS AVERAGE PENETRATION - INCHES PER YEAR X 1000)
NOTE: THE DATA COMPUTED FROM EQUATION:
$P = 0.46(0.1\ RC)^{0.52}$
WHERE P = RATE OF ATTACK UPON ORDINARY STEEL AS AVERAGE PENETRATION IN INCHES PER YEAR X 1000
R = RATE AT WHICH STEAM IS CONDENSED IN POUNDS PER HOUR
C = CO_2 CONCENTRATION OF CONDENSATE IN PARTS PER MILLION

Fig. 19—Data attesting to the relative corrosivity of the steam before and after installation of new boiler feedwater processing system. (Assumed condensing rate, 1000 lb per hr)

With the new water-treating system in operation, experience has demonstrated that water conditions are no longer the limiting factor. As a result, the continuous total boiler output is now considered to be 628,000 lb per hr.[3]

The extra capacity thus made available has been obtained at a cost of about $3.00 per 1000 lb. An equivalent amount of capacity could not have been provided by other means at a lesser cost. Because of this added capacity, the total investment in plant equipment per unit of available capacity is still not significantly different from what it was before the new water-treating equipment was added.

The fixed charges and operating costs per 1000 lb of steam produced are summarized in Table 9. These costs are felt to be equitable in view of the plant economies that have been effected, plus the fact that the steam is as free of corrosion-producing substances as modern science knows how to produce.

TABLE 9—OVERALL COSTS OF WATER AND TREATMENT*

	Cents per M-lb of Water
Fixed charges†	0.385
Water	1.000
Treatment	0.732
Total	2.117

* Based upon treatment of 1,250,000,000 lb of water annually and amortized over a period of 30 years.
† Calculated by equation.

$$\frac{C}{30} + \frac{0.12\ C}{30} \div 1{,}250{,}000 = \text{Figure shown}$$

where C = total installed cost, 0.12 C = interest on investment plus taxes, etc.

Summary

The system described is believed to represent the first attempt ever made, upon a commercial scale, to devise a water-processing method capable of producing CO_2-free steam from carbonate-bearing boiler feedwater. Data, reflecting the performance of the system, demonstrate that the chemical quality of the steam produced is on a par with that developed in carefully operated plants where only condensate is used for boiler feedwater and that operating costs are equitable. It is also shown that by careful planning, such a system may be provided at an overall plant cost not significantly higher than where a less exact method is used.

For large steam producers, at least, it is felt that such disclosures will have special significance because for many the use of a steam free of all deleterious substances appears to be the only means by which the heavy annual payments, imposed by corrosion, can be avoided.

Acknowledgments

Seldom, if ever, is a development of the magnitude of the one described the result of the efforts of one individual or even a small group. Rather, it usually reflects the talents available in a number of specialized groups. When such is the case and the completed project is written up in a manner suitable for publication, it becomes a most difficult task to prorate credit equitably to the many individuals concerned. Invariably when this is attempted it becomes evident, at some later date, that a real injustice has been done. As a result all concerned are embarrassed. Therefore, because of the large number of individuals who contributed in the present case, and the corresponding chance of embarrassment, it was deemed prudent to cite those groups that contributed in a conspicuous manner rather than the individuals. In accordance with this conclusion it is a pleasure to note:

That considerably more than a curtsy is due the Company's officers for having approved the expenditure necessary to such a development; that virtually all of the credit for designing the system and installing the equipment belongs to the Construction Engineering Department; that the enthusiastic help, given by the Purchasing Department, especially in negotiating some of the changes that became necessary, supplied much of the inspiration needed to follow such an undertaking to a successful conclusion; that the cooperation received from the plant personnel was an indispensable contribution without which the system could never have been proved practical.

The authors freely acknowledge that without the help of the many individuals who constitute each of these groups this report could never have been given.

[3] This figure does not include the largest boiler which is held as a spare, nor any increase in the generating capacity of the three oldest boilers.

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Commercial Gas Turbine Operation Now Achieved

Two major milestones marked American gas-turbine progress in 1949, the placing in service of the first central-station installation and the public exhibition of the first gas-turbine electric locomotive. This report reviews these accomplishments, provides an outline of the history of the gas-turbine, and examines future possibilities in terms of anticipated metallurgical developments.

TRANSFORMATION of a theoretical conception of energy conversion into a practical operating machine having commercial application is a long and tedious process, as is evidenced in the history of the steam engine and the steam turbine. The year just past marked the addition of the gas turbine to the roll of prime movers in commercial operation in America.[1]

The first central station gas-turbine installation in the United States was the 3500-kw General Electric unit which went into service on July 29, 1949, at the Arthur S. Huey Electric Generating Station of the Oklahoma Gas and Electric Company. About six weeks previously, on June 16, 1949, the General Electric Company and the American Locomotive Company made the initial public track demonstration of the first gas-turbine electric locomotive to be built and operated in this country, a 4500-hp unit which was later placed in freight service on the Union Pacific Railroad.

Gas-Turbine History

A succinct review of the history of the gas turbine discloses several marked periods of development. Hero made the first formulation of the fundamental principles of the turbine about 2000 years ago, and Leonardo da Vinci has been credited with devising a crude version of the gas turbine. Indeed, it has been said that the gas turbine has been the most frequently "invented" of all prime movers, its "creators" ranging from a Seventeenth Century English bishop to scientists of the highest type. The first important gas-turbine design was proposed in 1791 by John Barber, whose basic British patent covers compressors for air and gas, a combustion chamber, and an impulse wheel upon which the combustion products impinge. Nearly sixty years elapsed before Fernihough obtained a patent on a producer-gas turbine, followed in 1884 by C. A. Parsons whose concept, as covered in a patent description, is remarkably similar to the present development of the combustion gas turbine. Successful operation of a gas turbine over a three-year period was reported by Armengaud and Lemale in 1907, who, beginning in 1900, used a Rateau centrifugal-type compressor and a rebuilt steam turbine operating on combustion gases.

Sanford Moss of the General Electric Company began work on the gas turbine in 1901 and by 1907 had an operating turbine which, like the French machine, had an efficiency of about three per cent. It became clear that low compressor and turbine-wheel efficiency, in conjunction with the materials available in the early 1900's, made impossible the building of a gas turbine with satisfactory efficiency. Except for the continuing work of Karl Holzwarth in Germany on the explosion gas turbine, which proved to be more efficient but far more complex than the continuous-combustion type, efforts to develop a gas-turbine prime mover were for all practical purposes abandoned until the 1930's. However, the Swiss firm of Brown Boveri must be credited with accelerating gas turbine progress by its development of Velox boilers and axial-flow compressors in the years preceding World War II.

The most recent period of widespread American interest in the gas turbine dates from 1939 when Adolphe Meyer of Brown Boveri contributed an outstanding paper[2] dealing with fundamental economies and applications of the gas turbine to power generation, ship propulsion and railroad transportation. Many American designers and manufacturers became aware of the commercial possibilities of the gas turbine about this time, and among the numerous technical articles which followed mention should be made of several significant papers by Dr. John T. Rettaliata[3] and of a widely reprinted article by F. K. Fischer and C. A. Meyer.[4]

World War II stimulated interest in the gas turbine through a combination of air-craft application (with its attendant secrecy) and wide popularization which oft-times ascribed utopian properties and prospects to this type of prime mover. Like some other developments "glamorized" during the war, the gas turbine of the post-war era was a disappointment in the eyes of the general public, notwithstanding notable technical accomplishments by a number of companies engaged in the commercial development of the gas turbine. It might be written that 1949 marked both the initial successful commercial application of this prime mover and its return to widespread popular interest.

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[1] It is recognized that there are more than 35 gas turbines in operation in the United States in connection with the Houdry refining process and that a number of gas turbines have been built and subjected to intensive testing in this country.—EDITOR.

[2] Meyer, A., "The Combustion-Gas Turbine," *Mechanical Engineering*, Vol. 61, Sept. 1939, pp. 645–652.

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Central-Station Installation

As reported in November COMBUSTION, the 3500-kw gas-turbine unit that forms an extension to the Arthur S. Huey Electric Generating Station of the Oklahoma Gas & Electric Company was placed in service on July 29, 1949. This gas turbine is of the two-stage, open-cycle type and is fired by natural gas. It drives a 15-stage axial air compressor and a 3500-kw generator through a 6700–3600-rpm reduction gear. Incorporated with the unit is a Combustion Engineering recuperator which recovers heat from the exhaust gases to heat feedwater for the adjoining steam plant. Results to date have shown that the gas turbine has not only performed satisfactorily as an independent unit, but that it has also contributed to the overall plant output and efficiency. Costs for this gas-turbine installation are $208 per kilowatt of rated capacity or $104 per kilowatt, taking into account maximum capability of the unit and crediting plant cycle gains due to the recuperator. Heat rates for September 23 showed values of 21,960 Btu per kwhr for the gas turbine only and 16,220 Btu per kwhr for the combination with the steam plant.

Gas-Turbine Electric Locomotive

The Alco-G-E gas-turbine electric locomotive is designed with a straight-through in-line arrangement of compressor, combustion chambers, and turbine. The gas turbine is connected through gearing to four generators from which power is supplied to eight traction motors, each driving one of the eight locomotive axles. Pressure ratio of the 15-stage axial-flow compressor is 5.9 to 1. Starting of the unit is by operating one of the main locomotive generators as a motor and supplying power from a diesel-engine-driven generator. Diesel fuel is used for ignition in starting up, after which a transfer switch is actuated for operation with Bunker C (No. 6) fuel oil.

Although problems remain, including control of certain objectionable exhaust sounds and provision for reversed train operation in tunnels, the obstacles thus far faced are not attributable to the gas-turbine plant itself.

Development and Testing of Gas Turbines

In this account of commercial operation of gas turbines in the United States, sight must not be lost of the extensive development and experimental testing carried on in the United States by Allis-Chalmers Mfg. Co., De Laval Steam Turbine Co., Elliott Co., and Westinghouse Electric Corp. At least three of these companies are building, or have in advanced stages of design, gas turbines for application to locomotive use, burning either pulverized coal (on which encouraging preliminary operating tests have been conducted) or heavy fuel oil. Successful operation with inlet temperatures of 1500 F of a 3500-hp gas-turbine plant at Annapolis has been revealed by the U. S. Navy and Allis-Chalmers Mfg. Co. The closed-cycle gas turbine has received much attention, both in this country and abroad. In Switzerland, Escher Wyss is undertaking extensive development relating to the closed cycle, and it is reported that Westinghouse Electric Corp. is developing a modification of the closed-cycle gas turbine in this country.

Progress in Metallurgy

The future of the gas turbine is largely dependent upon progress in metallurgy, and particularly upon the development of metals for long-life gas turbines. A paper by N. L. Mochel[5] at the 1949 A.S.M.E. Annual Meeting incorporated a comprehensive review of the present state of metallurgical art with respect to long-life gas turbines. The following digest from that paper is included because of its significant relationship to progress that may be expected in further commercial applications of the gas turbine.

Up to the present the development of materials for such short-life apparatus as jet engines, prop-jets, ram jets, and rockets has received more research and testing support than have problems related to the non-aviation gas turbine. It is altogether possible that studies and conclusions based upon small sizes of units and designs having limited lives (on the order of a few hundred hours at most) may not be applicable to larger gas turbines having far longer lives (on the order of years). Thus far there has not been the same degree of collaboration and urgency in non-aviation gas-turbine field that has characterized the aviation applications which are more directly related to national defense.

Materials for compressors, gears, auxiliaries, and heat-exchangers are probably available in sufficient development for present needs. While interesting and complex corrosion problems have arisen in connection with heat-exchangers for gas-turbine service, it is believed that there is a sufficient variety of materials in requisite shapes to meet future conditions for this service.

Mechanical Construction

The rotor of the gas turbine is of particular metallurgical concern at this time. Various manufacturers have employed or contemplate using such techniques as single-piece rotor forgings, the building up of multi-stage rotors by welding disks and stub shafts together, the welding of a composite wheel in a manner similar to jet-engine practice, and the mechanical fastening together of disks to form a multi-stage rotor.

Gas-turbine blading or buckets may be produced by machining from rolled and heat-treated bars or special shapes, by drop forging and machining as required, and by precision-casting methods. Machining is the cheapest and most reliable production method, though it is wasteful of critical materials. Drop forging and machining provide a fair amount of freedom with respect to design shape, but costs are adversely affected by die upkeep and life. Precision casting offers a means of avoiding previously noted objectionable features, and it may become the most economical method as casting techniques undergo improvement. Hollow blades may also deserve serious consideration because they may save critical materials, permit cooling, and result in lower stresses on blade fastenings.

In the future molybdenum and molybdenum-base alloys will receive much attention. However, means will have to be found for coating the parts with an impervious protecting surface which can prevent molybdenum oxidation. Other groups of alloys under consideration for high-temperature parts in gas-turbines include those with bases of chromium, titanium, and tungsten.

Mochel, N. L., "Metals for Gas Turbines," A.S.M.E. Paper No. 49-A-85.

TO IDENTIFY CORROSION

The following chart is taken from a paper on "Marine Boiler Deterioration," by I. G. Slater and N. L. Parr, before the Institution of Mechanical Engineers (Great Britain) and printed in its recently issued Proceedings. The corrosion problems covered are not limited to marine boilers but apply to stationary practice as well; hence the tabulation should be useful to many such operators in tracing the cause of corrosion.

FORMS OF BOILER DETERIORATION

Classification				Appearance of corrosion	Usual location	Cause
Boiler Deterioration	Internal Deterioration	Pitting	Air bubble pitting	Isolated hemispherical pits, often covered with a cap of loose soft corrosion products, which when dry is of black iron oxide covered with a membrane of red dehydrated ferric hydroxide.	Mainly on the roof of steam and water drums, but likely to be found on any surfaces in contact with water, where air bubbles may collect.	Liberated air bubbles attaching themselves to metal surfaces, thereby initiating anodic attack by the generation of localized electrolytic action.
			Scab pitting	Deep localized pitting covered by a scab of hard scaly black magnetic iron oxide which cannot be removed by wire brushes.	In hotter areas of heating surfaces where corrosion products are formed and rapidly consolidated into a hard scab by the heat. This is possibly the main form of deterioration encountered.	Use of untreated impure boiler water containing dissolved salts and gases in comparatively small concentrations so that *p*H of water lies between 4·8 and 9·4.
			Soft scab pitting	Broad, shallow pitting covered with caps of fairly hard corrosion products, usually black magnetic iron oxide covered with a layer of red dehydrated ferric hydroxide.	In superheater tubes and headers and in main steam lines.	Deposits of salts by priming in superheaters, main steam lines, etc., followed by condensation when the boiler is shut down, resulting in the formation of droplets of electrolyte and the initiation of a pit by differential aeration.
		General Wastage	Tube wall thinning	A general reduction in tube wall thickness over comparatively large areas, often without the presence of blankets of corrosion products.	Fairly evenly distributed over water surfaces with a tendency to be more pronounced in hotter areas.	Use of acid feed water.
			Necking and grooving	A circumferential band of corrosion on the water-side of fire tubes, stay tubes, and stay bolts in Scotch boilers.	Where stay bolts, stay tubes, and fire tubes enter end plates or combustion chambers.	The influence of adjacent end plates on expansion and contraction, resulting in stresses which cause repeated localized flaking of protective films.
			Galvanic attack	Local reduction in metal thickness.	Adjacent to non-ferrous boiler mountings, in areas of non-homogeneity of steel composition or at breaks in surface films.	Use of dissimilar metals in contact (or at areas of non-uniformity on the metal surfaces) in the presence of an electrolyte, when a difference in potential will result in sacrificial electrolytic attack at the anode.
		Corrosion Fatigue	In tubes	Network or series of cracks over the water-side of tube surfaces.	In boiler and superheater tubes on the hottest side of the bores. It is most frequently found in inherently curved tubes or tubes which have been buckled in service.	Irregular circulation in tubes causing frequencies of alternate over-heating and cooling which induce pulsating thermal fatigue stresses in the walls. Cracking is accelerated by residual stresses and a corrosive environment.
			In steam and water drums	Fissures, usually difficult to detect due to covering layers of corrosion products; usually associated with deep pitting.	Commencing at the arbouring in tube plates and extending axially, eventually joining two or more holes.	Bending stresses due to lack of common neutral axis between tube and wrapper plate, and excessive cold working due to initial rough machining operation. Accelerated by thermal stress and corrosive environment.
			In main steam pipes	Lines of cracks on bores of pipes.	On the bores of main steam pipes, especially in the base of corrugations.	Bending stresses due to movement during operation in the presence of a corrosive environment.
		Strain age embrittlement		Spontaneous cracking in boiler components during detubing or cleaning operations.	Between tube holes in tube plate, under rivet heads, round top end of tubes adjacent to the rolling surfaces.	Reduction of impact properties by the combination of cold work and ageing. Spontaneous failure occurs only at and below room temperature.
		Caustic embrittlement		Fissures in boiler plates, etc.	In boiler plates, radiating from and often connecting adjacent rivet holes, joints, arbourings, etc.	Joint effect of a combination of non-uniform stressing, and high concentration of caustic soda in the presence of a catalyst at high temperatures.
		Deterioration at Elevated Temperatures	High temperature oxidation	Continuous layers of hard black magnetic iron oxide scale.	Internal—in fire row and superheater tubes; occurring in drums and headers. External—on surfaces in contact with furnace gases.	Internal—poor circulation resulting in overheating in a steam atmosphere. External—local flame impingement or poor circulation or presence of heat insulating scale on water side.
			Bursts	Longitudinal gaping split which may or may not be associated with ballooning.	Hottest side of generator or superheater tubes.	Water starvation, resulting in over-heating with corresponding reduction in mechanical properties of the tube until bursting occurs under working pressure.
	External Deterioration		High temperature Creep cracking	Cracking and splitting associated with layers of high temperature oxide scale on tube surfaces.	In superheater tubes.	A combination of stress due to restricted expansion and overheating at temperatures around 550 deg. C.
		General wastage by damp soot		Localized wasting of boiler metal which can only be seen after removal of soot deposits.	Wherever soot collects, especially where tubes enter lower drums and headers.	Presence of sulphuric acid formed by action of moisture (when shut down) on oxides of sulphur present in the oil fuel soot.

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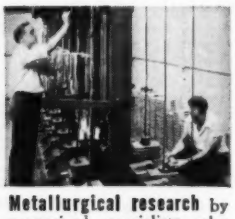

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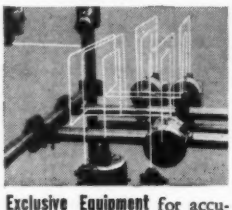

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Experimental Stoker-Fired Incinerator Furnace

By FRANCIS C. HOLBROOK

Mechanical Engineer, Department of Sanitation, New York

To replace hand-firing of an incinerator a pilot installation was made, involving continuous feeding of hogged refuse onto the grate of a Coxe traveling grate stoker provided with preheated air. The results were highly satisfactory and form the basis for the design of new installations.

PROGRESS in the field of municipal and industrial incineration has been highlighted by the gradual development of new types of mechanical stokers and the preparation of refuse to fit the burning characteristics of their particular design. Much ground has been covered through experimentation and test and the adoption of this method of reduction has gained the support of public officials and private interests alike.

Various types of mechanical stokers for the incineration of mixed refuse, together with special furnaces to conform to combustion requirements, have been built

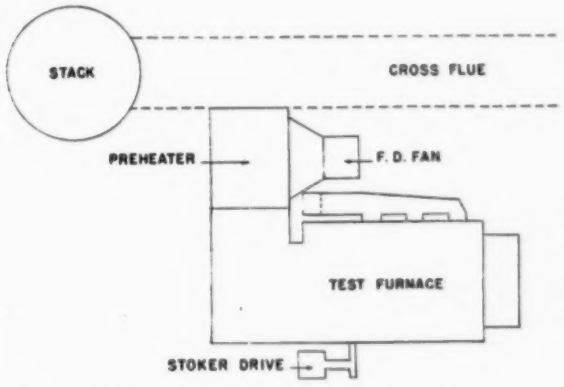

Fig. 1—Plan of furnace layout

and operated with varying degrees of success. These have ranged from the small Nichol's Monohearth to the huge Volund rotating kiln; but unfortunately they have not had the general use merited by their performance. With few exceptions these mechanized furnaces were restricted to patent limitations and did not envisage the use of universally standard equipment as employed for the combustion of other fuels.

New York City Experiments

For the past few years New York City officials in their efforts to reduce costs and to reduce or eliminate the arduous and sometimes demoralizing hand labor associated with the existing method of refuse disposal, have considered the advantages of mechanical stoking. To this end the Department of Sanitation approved the purchase of a Coxe traveling grate stoker for installation at its Ravenswood Destructor Plant, and after certain modifications in feeding arrangements, furnace design

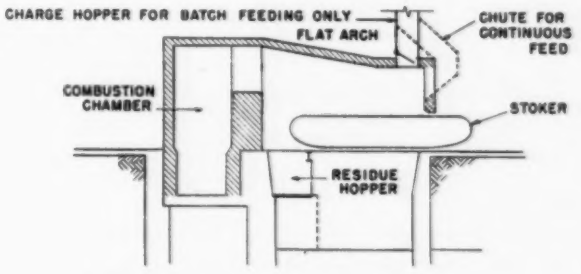

Fig. 2—Cross-section of test furnace

and residue removal, a comprehensive test was conducted to check and observe the relative burning and feeding characteristics of hogged and of "as received" mixed refuse.

The furnace and stoker equipment were erected on the foundation of an old hand-operated Decarie furnace which had been removed for this purpose by department labor. Fig. 1 is a sketch of the plan layout. It was built to conform to the contour of the stoker and consisted of $13^1/_2$-in. uninsulated refractory side and end walls and a flat 9-in. American arch so formed as to provide an increasing cross-section of furnace in the direction of grate travel to permit expansion of the products of combustion; see Fig. 2. These gases passed over a bridgewall at the rear of the furnace to a combustion chamber set at right angles to the furnace chamber, thence to a refractory preheater and to the chimney. Three observation and one stoking door (provided in case hand stoking should become necessary) were placed at strategic points in the furnace walls.

The stoker was driven by an 8-ft wide, 2-hp motor at speeds of 30, 45 and 60 ft per hour, adjusted to suit the nature of the refuse, which contained varying mixtures of garbage and rubbish, metal scrap, tin cans, cartons and ashes. Moisture varied with the source of the material

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and weather conditions and at times ranged from 50 to 60 per cent. At other times it was necessary to add water to prevent early ignition and a tendency to backfire into the feeding hopper, when dry material was fed to the unit.

Refuse was fed to the furnace by two trial methods. The first of these, indicated by the solid lines in Fig. 2, consisted of a vertical charging hopper with a bottom dump gate for batch feeding through the arch at the front of the furnace chamber. The fireman charged the furnace periodically when the fire had progressed sufficiently to receive the charge on the moving stoker. This method of feeding required occasional hand stoking because of the failure of the refuse to spread fully over the stoker.

The second trial method involved the installation of an inclined chute for continuous feeding through the front wall of the furnace to replace the vertical charging hopper. This is indicated by the dotted line in Fig. 2. An immediate improvement in ignition and firing was observed and was reflected in an increase in burning rate. Moreover, an analysis of the residue indicated better combustion and an absence of heavy clinker.

A forced draft fan, shown in the plan outline, Fig. 1, supplying preheated air, was operated intermittently to observe air pressures and temperatures and the effect upon furnace operation. Three pressure zones were furnished with the stoker and air adjustment was made by dampers which were an integral part of a special duct leading from the preheater to the furnace. Air temperatures ranged from 160 F to 260 F and pressures at the entrance to the stoker ranged from $^3/_4$ to 1 in. static pressure.

A small hogging machine was installed at the charging floor level to supply a quantity of shredded refuse. This was to study comparative operation with the raw material. It was found necessary to stockpile this refuse since the size of the hogger was too small to maintain a constant supply for furnace consumption. However, feeding was accomplished in units of 30 to 40 cu yd which was sufficient to observe the flow and burning characteristics.

Residue was received and quenched in a steel-plate hopper having a horizontal counterbalanced gate approximately 36 × 36 in. and three vertical sides with the fourth side sloping back to the full eight-foot width of the stoker.

Conclusions

Conclusions arrived at after five months of operation for an average of six days per week were as follows.

1. Traveling horizontal grate stokers are both practical and economical for such municipal incineration.
2. Hogging provided a better combustible mixture.
3. Continuous or mass feeding was superior to batch feed.
4. Residue was practically free of burnable matter. Moreover, it was free of clinker and resembled a loose and fluffy ash.
5. Mixed and hogged refuse were auto-combustible.

The conditions governing the installation and subsequent operation were necessarily crude; but, despite the difficulties of adaptation, the results were highly satisfactory and provided sufficient data for the design of new installations and the conversion of existing hand-operated plants.

Liability for Failure to Supply Water, Gas and Electricty

From time to time questions arise as to who is liable for damages resulting from interruptions in water, gas or electric supply. This article cites specific legal cases concerned with problems of this sort and explains briefly the underlying principles of law that must be considered.

By LEO T. PARKER Attorney at Law, Cincinnati, Ohio

RECENTLY a reader wrote as follows: "We have a law suit on our hands. A few months ago you cited higher court cases which assisted our attorney to win a suit. Can you repeat? Here is our question: When is a municipality liable in damages for failure to supply water for operation of a steam plant? Several weeks ago a water main burst and we were compelled to shut down our steam plant for lack of water. The result was we lost considerable money. Is the city liable for our loss? Please explain when a city or utility corporation is liable in damages for cutting off water, gas and electric supply which compels shutting down steam-operated plants. Another important question that has arisen in the past is whether a city or water corporation is responsible to steam-operated plant owners for financial losses resulting from negligence of the officials and employees of the city or of the utility corporation."

$80,000 Damages

First, it is well to review a leading higher court decision holding a municipality liable in damages where it was shown that negligent operation and administration of its sewerage and water department resulted in pollution of water utilized by a private corporation. This important case was *Southern New England Ice Company v. West Hartford, 159 Atl. 470*, reported July 1948.

The facts of this case are that a municipal sewer system overflowed and discharged raw sewage into a stream. The water from this stream was utilized in the manufacture of ice by a company which filed suit to recover damages. The court held the ice company entitled to recover $80,000 damages, and said:

"...It is no defense that the defendant (city) was a municipal corporation and the pollution was the result of its efforts to dispose of the sewage from the dwellings and other buildings of its inhabitants."

Must Prove Negligence

Courts consistently hold that neither a municipality, a water, gas or electric corporation, or other utility company, is liable in damages for cutting off its supply unless the testimony shows that the corporation's officials or employees were negligent.

In fact, in legal controversies involving financial loss to a plant owner the important consideration is: Did the officials and employees of the utility company use the same degree of ordinary care to prevent the damage as would have been used under the identical circumstances by other prudent and experienced officials and employees? When this question has been answered in the affirmative by a jury the city has not been adjudged liable.

With reference to the term "ordinary care," the higher courts have consistently held that failure to use "ordinary care" is negligence. In fact the lack of ordinary care and negligence appear synonymous from a legal standpoint.

Negligence Is Apparent

Obviously, a city is liable for damage to private property whose owner proves that a leaking water main or pipe is owned by the city whose officials failed to act on advance information that the line was defective or leaking.

For example, in the case of *Egelhoff v. City, 267 Pac. 1011*, it was disclosed that in 1891 the city constructed a wooden-stave pipe line for the purpose of conveying water for use of the city and its people. The pipe was 2 ft diameter and was constructed along a mountain side. Thirty-five years later a large quantity of earth and rock slid down from the mountain, undermining and breaking the main. Suit was filed against the city for damages and it was proved that the slide was the result of the pipe line being old and rotten, thereby permitting water to leak from the line and soften the ground.

During the litigation, certain plant owners introduced testimony showing that many times they had notified the water department that the pipe line was defective, and that at various times repairs were not properly made. In view of this testimony the higher court held the municipality liable, saying:

"...There is substantial evidence to support the finding of the jury that the slides were caused by the negli-

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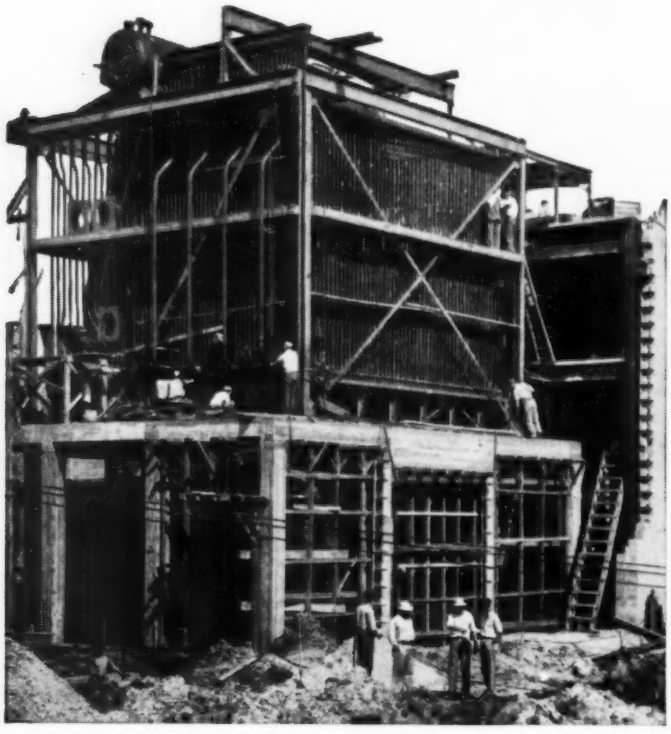

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A SERVICE ORGANIZATI

gence of the defendant (city) in its manner of constructing the pipe line and its failure to keep the same in repair."

Also, see *Riegel & Company v. City of Philadelphia 145 Atl. 837*, where the owner of a service plant sued a municipality for $17,128 damages sustained as a result of a water main bursting and flooding the lower floor of a building.

Evidence was introduced proving that the city waterworks department had been notified, several days prior to the time the main burst, that water was seeping from the ground adjacent to the building which was later flooded. At this time the city waterworks repair men examined the premises, but failed to turn off the water until the main burst.

In view of this testimony the court held the city liable, saying:

"The city had ample notice that there was a leak in the street from its water system. In the light of the notices received, it was its duty to investigate all its water pipes in the street until the source was found."

The importance of this court decision resides in the apparent requirement by the courts that utility company's officials and employees, whether municipal or private, must investigate and repair all pipes and apparatus owned and controlled by it in the location of a known leak. Failure to do so will result in liability.

Another important point of law is that if a city official orders a municipal employee to inspect service pipes owned and controlled by the property owner the city automatically and impliedly assumes liability for injury to property caused by negligence of the employee who carelessly makes the inspection, or failed to remedy the leak. Conversely, when a plant owner contends that damage did not result from leaks from his pipes, he must prove such contentions, otherwise he cannot recover a favorable verdict of any kind of a suit in which leakage is involved.

For illustration, in *Stern v. Wagenheim, 144 Atl. 118*, it was disclosed that a very large and excessive water bill was sent to the plant owner, who failed to prove that the leakage occurred outside his premises. Therefore, the court held him liable and required him to pay for the water quantity indicated by the meter.

For further leading higher court cases involving various phases of "control" of leaky water and gas mains and pipes, see *Castle, 199 S. W. 300; Fisher, 151 Mo. App. 530; Neal, 218 S. W. 35; Lucos, 173 S. W. (2d) 629; Gerger, 198 S. W. 78; Woods, 58 Mo. App. 272; Taylor, 111 S. W. 609; Wintle, 8 S. W. (2d) 61; Contrell, 169 S. W. (2d) 203; Jones, 168 S. W. (2d) 507; and Merrill, 44 S. W. 462.*

Each of these courts held that if a leak or disruption of water, gas or electric supply occurs in pipes, equipment or apparatus *owned* and *controlled* by a plant owner, the municipality or utility company is not liable unless its employees undertook to make repairs and were unsuccessful in doing so.

Allowable Damages

It has been held that the amount of damages collectable by a plant owner for loss of profits and inconvenience caused by the shutting off of gas, water or electric service may be based upon the reduced profits which the plant owner proved he suffered. On the other hand, courts hold that the plant owner must prove *actual* loss of profits but that anticipation of deprived profits is too remote and speculative to form proper basis on which to determine damages. For example, in a recent case, *Wills, 58 Atl. (2d) 161*, proof was introduced by a plant owner showing "inconvenience" resulting from turning off his gas supply. However, no financial loss was proved and the court held the gas company not liable.

However, the higher court will approve damage allowance "estimated" by a jury when the testimony indicates positively a financial loss to the plant owner resulted from negligence of the utility.

By Necessity

Usually, higher courts agree that neither a city nor a utility company is liable in damages for cutting off supply by necessity, especially if it is necessary to do so in order to safeguard lives.

For instance, in *Coyle v. Gulf Public Service Company, 155 So. 252*, it was shown that a fire broke out in a customers plant and, while it was raging, the water company's employees found it necessary to shut off a large pump, at the same time severing high-tension lines damaged by the heat. The owners of property filed suit against the water company to recover damages on the grounds that, first, the company had guaranteed to maintain a high pressure of water in the fire hydrants; and, second, it was negligence for the company's equipment to be so defective as to render necessary stoppage of the water pump for twenty minutes while the wires were being severed. However, the lower court held the company not liable and the higher court sustained the verdict, saying:

"It was necessary to cut the electric wires, to avoid the danger that they might fall upon and electrocute someone...."

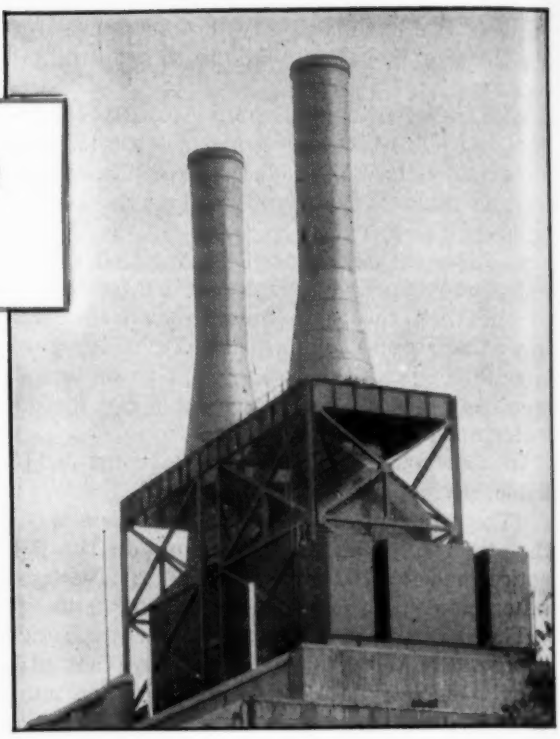
Also, *see Wankesha Gas and Electric Company v. Wankesha Motor Company, 190 Wis. 190.* Here a plant operator claimed damages because a gas company failed to furnish an adequate supply of gas for the operation of its plant. The testimony showed that there were temporary interruptions in service, but the court found that the causes of the interruptions were beyond the control of the gas company and held the company not liable.

And in *Bissel v. Eastern Ill. Utility Company, 222 Ill. App. 408*, the court held that a utility company's liability was *not* that of a guarantor. In other words, under no circumstances is a utility company an "absolute insurer" that it will supply continuous service unless it contracts to do so. Some higher courts have held that such a contract is valid, see *Arkansas, 164 S. W. (2d) 1000.* This court held that a gas company may make a valid contract to supply uninterrupted service, and if for any reason its service is interrupted the company is absolutely liable.

Rules and Regulations

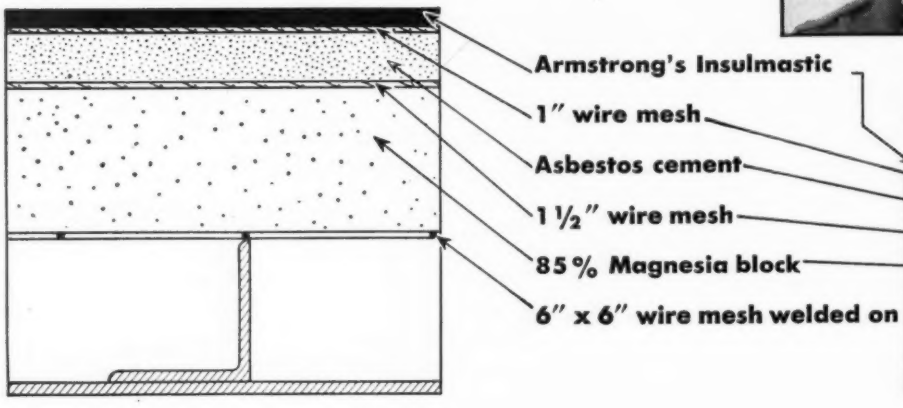
Higher courts agree that rules and regulations are valid by which utility companies require bills for service to be paid before a certain or specified date. Hence a utility company is not liable if its supply is cut off from a plant owner who failed to comply with reasonable rules and regulations.

How would you insulate these dust collectors?

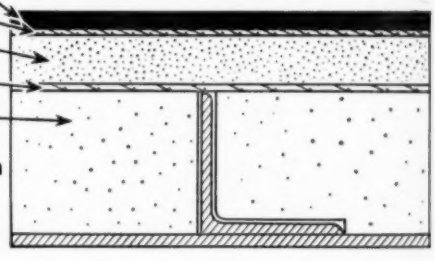


To prevent moisture condensation and corrosion inside these dust collectors, they are to be insulated with a layer of 1½" thick 85% Magnesia. How would you apply the insulation?

METHOD A.
Over stiffeners on collector shell



METHOD B.
Between stiffeners on shell



Here's what the Armstrong engineer recommended:

Of the two methods shown above, the application of the insulation over the stiffeners is most practical. The insulation is applied over 6" x 6" wire mesh, welded to the stiffeners. This mesh absorbs considerable "weave" and guards against the insulation's cracking as the collectors expand and contract. Also, the cost of applying the insulation over the wire mesh is lower than fitting insulation between the stiffener angles.

Method A also has the advantage of providing full insulation protection over the entire surface. In method B, the only protection over the stiffener is the wire mesh, plaster, and Insulmastic finish. The "weave" of the collectors will cause cracking at these points.

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On the other hand, it is important to know that this rule of the law is not applicable with respect to collateral obligations not directly connected with payment of water rates. So held a higher court in the case of *Pennsylvania Chautauqua v. Public Service Commission (160 Atl. 225)*. Here a water company adopted rules and regulations which required consumers to maintain their property and surroundings in a neat condition.

A water user failed to abide by this rule and the water company performed the service and assessed him the cost. The consumer refused to pay this amount and the water company cut off his water supply. He filed suit against the water company on the grounds that the water company could not legally cut off his water supply to enforce payment of a debt not directly connected with the service supplying water. In upholding this contention, the court said:

"...It follows that appellant's (company's) action in cutting off water service to enforce payment of a *collateral* obligation of one of its patrons was wholly unjustified. The service cannot be cut off to force payment... of a collateral liability not connected with the particular service."

Law of Liens

It has been held by various courts that a municipality has no right to enact laws regulating the collection of water bills, unless such laws are authorized by a state law. Therefore, a city ordinance or a regulation of a water company is invalid which creates a lien upon real property to secure payment of a tenant's water bill, unless a state law authorizes making of such law. So held a higher court in the case of *Redge v. Norfold, 139 S. E. 508*.

Here it was disclosed that a city passed an ordinance which provides that whenever any water bill shall remain unpaid thirty days the water shall be cut off from said premises, and shall not be turned on again until all delinquent charges therefor have been paid in full.

The validity of the ordinance was tested when the city sued a property owner to recover the unpaid water bill of a tenant.

It is interesting to observe that the court held the above ordinance invalid, saying:

"...Neither the charter of the city nor any other statute provides a lien on property for water rents; nor is there any statutory authority, for the ordinance in question. This being so, said ordinance, insofar as it attempts to hold a property owner personally responsible for the payment of arrearages for water consumed by the tenant on the premises, is unreasonable and void.... The regulation is unreasonable in its effects, because it requires the property owner, as in this case, to pay the delinquent water bill of a former tenant, which he is under no obligation to pay, in order to secure another tenant and keep his premises occupied, and denies the incoming tenant the use of the water to which he is entitled when he occupies the premises and offers to comply with the regulations required of consumers."

On the other hand, in *Loring v. Boston, 163 N. E. 82*, it was shown that a state law provides that if the water charges due to a city are not paid within sixty days after becoming due the charge shall be a lien upon the real estate. In upholding the validity of the law and in holding a property owner bound to pay old water bills of tenants, the court said:

"The default of the tenant did not relieve the real estate from the lien which had been imposed by the superior public authority for the preservation of the public health and safety."

Fuel Oil Properties and Characteristics*

API gravity is a direct measure of the density of an oil and a good indication of its heating value. It also is indicative of the composition of oil. An A.S.T.M. distillation is a measure of the boiling range of an oil and is of importance in burner design. Flash point is the lowest temperature at which the vapor above the oil will burn if subjected to an open flame; it is a measure of the temperature at which oil can be handled without fire hazard.

Kinematic viscosity at 100 F is gradually replacing Saybolt viscosity measurements because it is a more accurate and more flexible test method. While detailed relationships of the effect of viscosity upon spray characteristics of gas-turbine fuel nozzles are not available, it is not expected that the design of atomizing equipment will present a difficult problem. The aniline cloud point is a measure of the paraffinicity of an oil, a low aniline point indicating an aromatic, naphthenic or a highly cracked oil, and a high aniline point denoting a paraffinic straight-run oil.

Sulfur content is important from a corrosion standpoint only when it is excessive. It has been shown that with the use of high-temperature type alloy steels even high-sulfur gases do not markedly increase the corrosion rate in gas turbines over that of air of the same temperature. Copper-strip corrosive tests measure the corrosive tendencies of an oil but are not conclusive except for extreme cases. Except where contamination is indicated, color is of little value as an index of oil performance characteristics.

Ash in fuel oils is derived in part from metals inherent in the crude oil, contamination during refining and the entrainment of such materials as rust and sea water. Some of these substances are injurious to brick work, while others cause slagging and deposits on superheater tubes in the form of oxides and sulfates. For gas-turbine operation high ash content may increase the rate of erosion of the burner chamber, turbine nozzles and blading. Refinery efforts to reduce ash in residual fuels thus far have not proved economically justifiable.

Fuel oil production generally is controlled by refinery operations for the production of more valuable products with suitable processing equipment all types of fuel oils can be converted to gasoline by thermal or catalytic cracking. Because refining operations are carried out to obtain the desired yield and quality of gasoline, it is impossible to exercise complete control over the characteristics of fuel oil produced at the same time.

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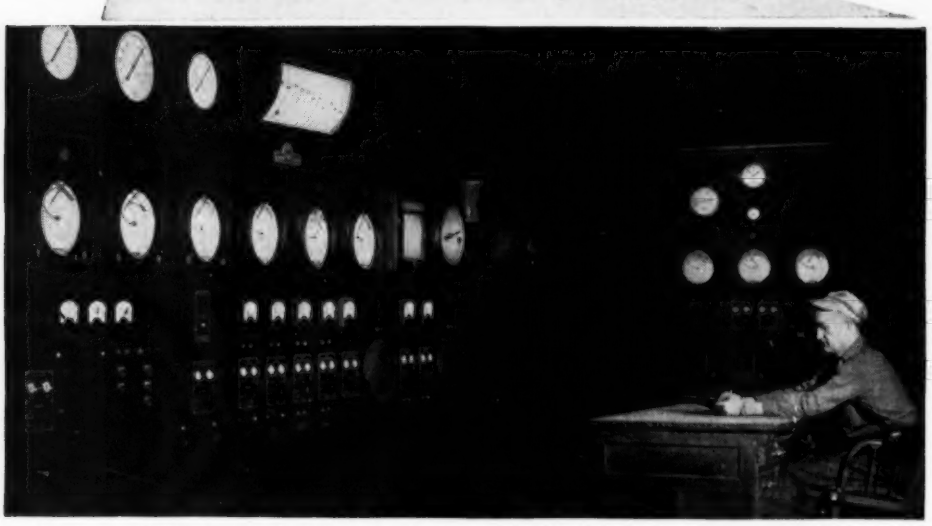
* From a paper by D. P. Heath and E. Albat before the 1949 Fall Meeting of the A.S.M.E. at Erie, Pa.



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Facts and Figures

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•

Since their introduction about 35 years ago, some 300 double-rotation, radial-flow steam turbines of various sizes up to 50,000 kw maximum have been built and installed abroad.

•

Caustic embrittlement is generally a combination of high concentration of sodium hydroxide, due to leakage, and high internal stress of the metal set up by the manufacturing or fabrication processes.

•

The 1950 Census, which will be taken during the month of April by approximately 140,000 enumerators, is estimated by the Department of Commerce to take $2^1/_2$ years to tabulate completely.

•

The first annual report of the British Electricity Authority (since nationalization of that industry) showed, on a 12-month basis, the average thermal efficiency for its steam stations to be 21.15 per cent.

•

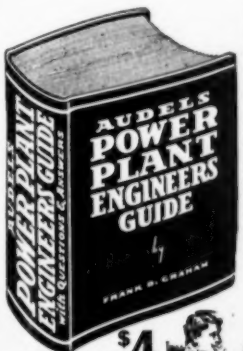
Production of electric energy by electric utilities in the United States during January exceeded 26,871,000,000 kwhr which was the highest monthly production of record, greater than that of December 1949 by 2.1 per cent.

•

In burning fuel oil, sodium compounds, and to some extent iron, will attack refractory furnace linings, when present in appreciable amounts. Also, sodium sulfate and vanadium compounds are largely responsible for deposits on superheater surfaces. However, they are largely water-soluble.

•

Discovery of an estimated 600,000,000 tons of semi-smokeless bituminous coal in the lower beds of the Georges Creek field in Maryland has been announced by the Bureau of Mines. These new reserves are below the two beds that have heretofore provided most of that field's output.



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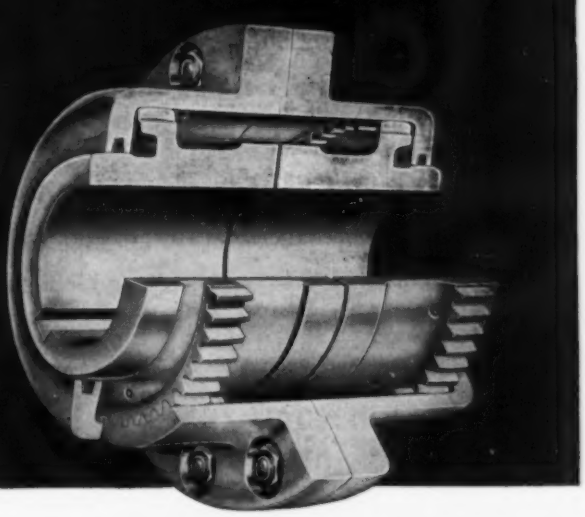

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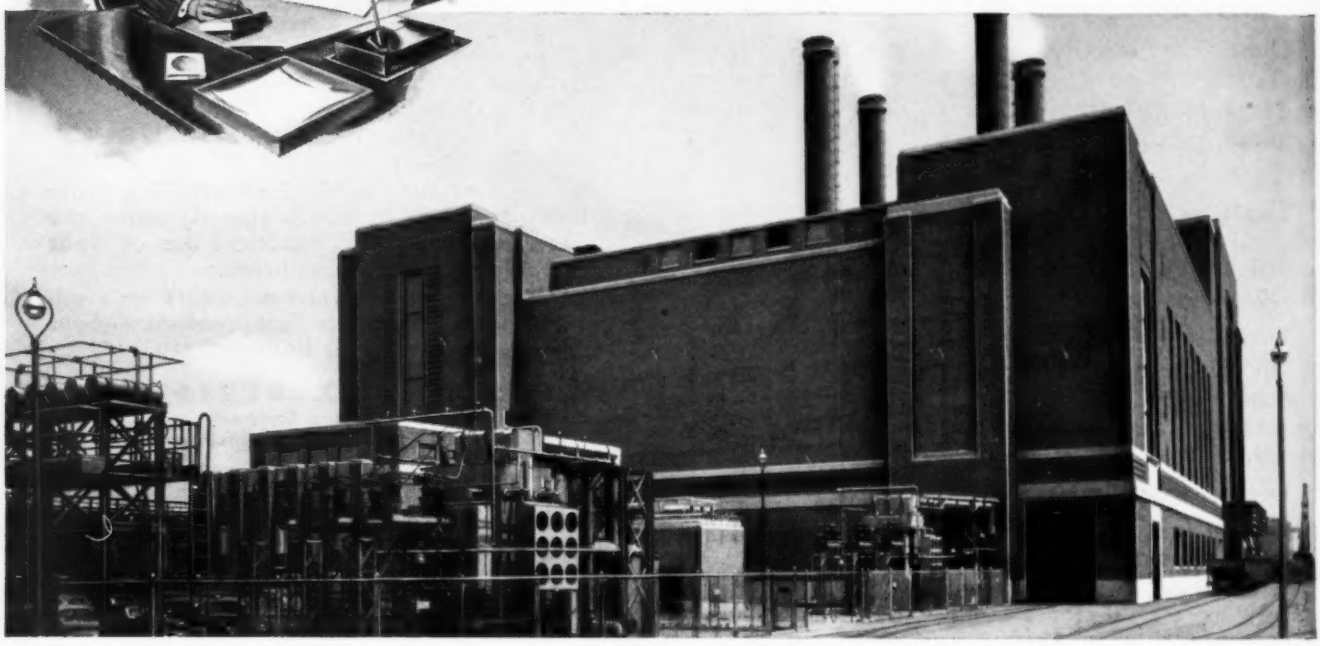

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A.S.M.E. Spring Meeting

WASHINGTON, D. C., will be the scene of the A.S.M.E. Spring Meeting, scheduled for April 12–14 at the Hotel Statler. In addition to a well-balanced technical program, a number of interesting inspection trips are planned, including the U. S. Naval Academy, the Bureau of Standards, the Lee mansion at Arlington, the Naval Ordnance Laboratory, the Taylor model basin, the new Potomac River Generating Station, as well as various sightseeing trips. There will also be a ladies tea at Blair House on Wednesday afternoon when Mrs. Truman will receive. Following is that part of the technical and general program of particular concern to power men:

Wednesday, 9 a.m.

"Test Experiences with the Annapolis 3500-Hp Experimental Gas Turbine Plant," by A. C. Skortz and F. R. Gessner, of the U. S. Naval Experiment Station.

"Fly Ash Collection for Small Plants," by A. A. Peterson, of Prat-Daniel Corp.

"Fly Ash Collection Equipment for Small Boiler Installations," by W. L. Prout of Green Fuel Economizer Co.

"Factors Influencing Dust Collection for Small Boilers," by H. O. Danz, of American Blower Corp.

Wednesday Noon

Welcoming Luncheon with President James D. Cunningham presiding and Senator Ralph E. Flanders as the speaker.

Following the luncheon there will be an inspection to the Potomac River Generating Station at Alexandria, Va.

Wednesday, 2:30 p.m.

"Marine Gas Turbine Research in Britain," by T. F. W. Brown of Parsons and Marine Engineering Turbine Research and Development Association.

"Prospects of Gas Turbines in Naval Applications," by W. T. Sawyer and R. T. Simpson, U.S.N.

"Measurement of Temperatures in High-Velocity Steam," by J. W. Murdock and E. F. Fiock.

"Optimum Tube Size for Shell and Tube-Type Heat-Exchangers," by F. D. Cardwell of Chemical Construction Corp.

"Loss Coefficients for Abrupt Changes in Flow Cross-Section with Low Reynolds Number Flow in Single and Multiple Tube Systems," by W. M. Kays, Stanford University.

"Local Coefficients of Heat Transfer for Straight Fins," by M. L. Ghal and M. Jakob, Illinois Institute of Technology.

Wednesday, 8 p.m.

Junior Conference on "How Is Your P. D.?," W. F. Ryan, of Stone & Webster Engineering Corp., presiding.

Thursday, 9 a.m.

"Latest Technique for Quick Starts on Large Turbines and Boilers," by J. C. Falkner, D. W. Napier and C. W. Kellstedt, of Consolidated Edison Co. of New York, Inc.

"Sealing of High-Pressure Steam Safety Valves," by R. E. Adams, Battelle Memorial Institute, and J. L. Corcoran of Manning, Maxwell & Moore.

"Training for Transition to Professional Responsibility," by William Oncken, Jr., U. S. Naval Ordnance Laboratory.

"Training for Career Development," by R. L. Randall, National Bureau of Standards.

"Developing Professional Competence in Industry," by J. C. McKeon, Westinghouse Electric Corp.

Thursday Noon Luncheon

Presiding: F. M. Feiker, Dean of Engineering, George Washington University.

Speaker: W. C. Foster, Acting Administrator of the Economic Cooperation Administration, who will discuss the Marshall Plan.

Thursday, 2:30 p.m.

"The Fluid Energy Pulverizer and Its Application to Steam Generation," by L. D. Bechtel, of Carroll, Bechtel & Langtry, and G. M. Croft, of Blaw-Knox Co.

"Practical Application of the Anthratube," by R. C. Johnson, The Anthracite Institute.

Thursday, 7 p.m.

Banquet, with W. L. Batt as Toastmaster; speaker and subject to be announced.

Friday, 9 a.m.

"Properties of Thin-Walled Curved Tubes of Short-Bend Radius," by T. E. Pardue and I. Vigness of Naval Research Laboratory.

"Investigation of Thermal Cracks in Large Turbine-Generator Rotor Forgings," by A. W. Rankin, C. J. Boyle, C. D. Moriarity and B. R. Sequin, of General Electric Co.

"Thermal Shock and Other Comparison Tests of Austenitic and Ferritic Steels for Main Steam Piping," by W. C. Stewart, U. S. Naval Experiment Station.

First A.I.E.E. Power Conference

On April 19–20 the local Pittsburgh section of the American Institute of Electrical Engineers will be host to the First A.I.E.E. Power Conference which will be held at the William Penn Hotel. A total of 18 papers, electrical and mechanical, will be presented in four sessions.

April 19, Morning Session

"Elements of System Capacity Requirements," by C. W. Watchorn, Pennsylvania Water and Power Co.

"Economic Evaluation of Unit-Type Generating Stations," by W. J. Lyman, C. E. Mullan and R. M. Buchanan, Duquesne Light Co.

"Survey of New Station Costs," by A. E. Knowlton, *Electrical World*.

"Fire-Fighting Problems in Generating Stations," J. J. Shoemaker, The Detroit Edison Co.

Afternoon Session

"Maintenance and Overhaul Scheduling," by W. C. Bryson, Duquesne Light Co.

"Steam Station Efficiency Control," by B. G. A. Skrotzki, *Power*.

"Efficient Use of Operating Personnel," J. A. Brooks, and F. Van Olinda, Consolidated Edison Co. of New York, Inc.

"Methods of Storing, Handling and Controlling Material and Supplies," by A. Gastler, Consolidated Edison Company of New York, Inc.

April 20, Morning Session

"Modern Trends in Industrial Electric Power Distribution," by D. H. McIntosh, Allis-Chalmers Mfg. Co.

"Systems Neutral Grounding in Industrial Plants," by D. L. Beeman, General Electric Co.

"Electrical System of a Pharmaceutical Plant," by J. M. Webb and R. H. Whaley, Eli Lilly & Co.

"Selection of Voltage for Industrial Plants," by H. B. Thacker, Westinghouse Electric Corp.

"Low-Voltage Switchgear for Large Commercial Buildings," by E. Burgin and A. Conangla, I-T-E Circuit Breaker Co.

Afternoon Session

"Using 600- and 460-v Power Systems With Grounded Neutrals," by J. E. Arberry, Pittsburgh Plate Glass Co.

"Minimizing Industrial Production Losses From Voltage Dips," by E. L. Tornquist and E. A. Armstrong, Public Service Co. of Northern Illinois.

"Supplying Power to Industry," by F. F. Dickman, West Penn Power Co.

"Application of Capacitors to Industrial Systems," by J. E. Barkle and R. N. Bell, Westinghouse Electric Co.

There will be a registration fee of $2 and reservations should be made directly with the hotel.

Water Treatment Courses in Newark and Baltimore

The Drew "Water Course" which has previously been favorably received by plant managers, superintendents, engineers, chemists, etc., in New York, Cleveland, Detroit, Chicago, Cincinnati and other industrial centers, will again be given this spring in Newark and Baltimore.

This course consists of a series of four lecture and discussion meetings covering the fundamentals of water chemistry; industrial water problems; plant problems such as steam and condensate lines, heat transfer equipment, service water lines, air conditioning equipment, evaporators, etc.; and the interpretation of water tests. The sound motion picture, "A Study of Water," filmed in the Drew laboratories, will be shown. It will be conducted by Dr. R. C. Ulmer, technical director of the Power Chemicals Division of E. F. Drew & Co., Inc., and meetings will be held as follows:

Newark, N. J.—April 6, 13, 20 and 27, at the Hotel Sheraton, 8:00 p.m.

Baltimore, Md.—March 28, April 4, 18 and 25, at the Engineers Club.

Pacific

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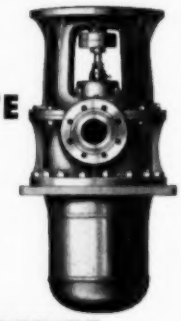

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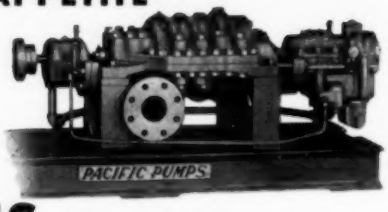

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45,000 to 475,000 lbs. per hour
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DISCHARGE PRESSURES: To 1000 PSI

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To 1,200,000 lbs. per hour
TYPES ABF and IBF
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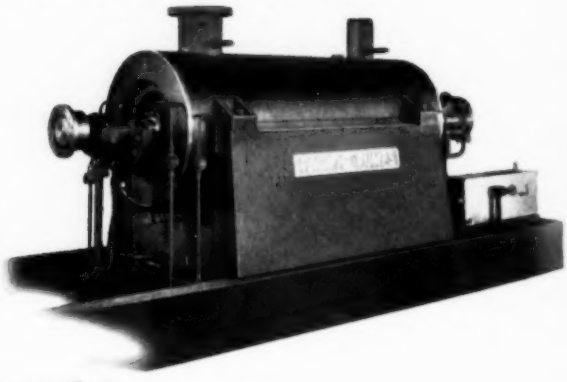

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YOUR PLANT ENGINEERS . . . because they require minimum attention and maintenance; because they are precision-built from materials selected for high resistance to corrosion-erosion and because they are balanced dynamically and hydraulically to eliminate vibration and excessive wear.

YOU, THE OWNER . . . because of their dependability; sustained efficiency and low cost of operation and maintenance.

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BF-5

One Man Push Button Operation Only a Dream, Engineers Are Told

Although increasing costs of operating personnel are giving greater emphasis to centralized control, the dream of operating a steam-electric power station by one man sitting in a small air-conditioned office watching a single dial and twisting a single control handle to solve all operating problems is only a cartoonist's exaggeration, according to B. C. Mallory of Stone & Webster Engineering Corporation who spoke at the Winter General Meeting of the American Institute of Electrical Engineers at the Hotel Statler, New York, on January 31.

"For one thing," Mr. Mallory said, "present-day equipment and controls are not sufficiently trouble-free, even with the best maintenance programs, and are not trusted to operate satisfactorily without adequate attention; nor, have automatic controls been devised to start either a turbine or a large high pressure boiler from cold without manual assistance and careful checking by operators.

"The amount of advantageous centralization revolves about the number of manual controls that can be handled by one man in time of trouble, he continued. One man can supervise many controls while everything is functioning properly, but in time of trouble the number and complexity of the controls that one man can handle depends to a large extent on the panel layout and the ability of the man."

Mr. Mallory described a recently constructed steam-electric power plant with only two boilers and two generators in which a centralized panel control board was installed. The boiler control panels "of even this relatively minor arrangement," totaled 38 ft, and contained 84 indicators, 36 recorders, 12 controllers, 50 sets of start and stop switches with an average of 3 lights to a switch. The turbine panels totaled 26 ft and contained 14 indicators, 20 recorders and 16 sets of start and stop push buttons averaging 3 lights to a switch.

"A vast amount of thought and effort should be applied to developing reliable controls for automatic starting of boilers and turbines," Mr. Mallory stated, "especially from an overnight standby condition. Managements are asking engineers to consider seriously some automatic time-clock device, possibly with temperature and vibration sensitive adjustments, to coordinate starting procedures properly, both from the viewpoint of uniformity of operation and ease of control."

The following four points were listed as major disadvantages of complete centralized control of steam-electric power stations with switchboards located in the control room:

1. Space required for control room in heart of station. This adds to initial construction cost by increasing building space and may add it for the full height of the station.
2. Each additional instrument and control adds equipment to be maintained and each is a poten-

Over 450 Aldrich-Groff Pumping Units—many with as much as nine years of service—are successfully operating today. And over 450 Aldrich customers have known and profited by a good investment. This service approaches that desired by Aldrich Pump designers and builders.

These many years successfully passed prove the endurance and low upkeep that are built into the Aldrich-Groff "POWR-SAVR"—a constant speed, controllable capacity pump. Its most obvious worth is usually associated with its stroke transforming action—supplying only that pressure actually needed. Less obvious is its long service economy.

For long service in the power field, for boiler or desuperheater feed, the Aldrich-Groff "POWR-SAVR" above, eliminates loss of power; and, as for mechanical reliability—there stands nine years proof of successful operation.

Send for material giving full details and ratings of Aldrich-Groff "POWR-SAVR" Controllable Capacity Pumps.

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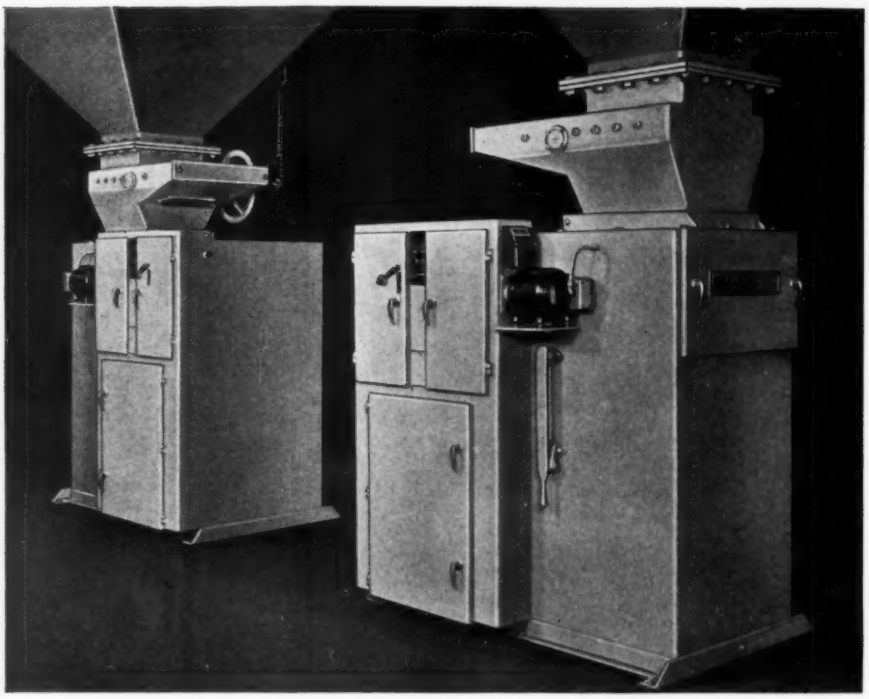
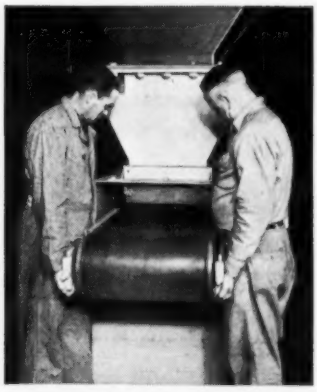


ENDLESS FEED BELT EASILY CHANGED

on S-E-CO. COAL SCALE

It is a simple procedure to replace an endless feed belt on a S-E-Co. Coal Scale. Remove two pins in the by-pass linkage, withdraw entire feeder through the feeder access door, set feeder on its side as shown in the photograph, loosen belt, remove—that's all—two man-hours are more than enough for complete belt replacement.

Easy replacement of the endless feed belt is but one of the many features that make the S-E-Co. Scale the one to use in your boiler plant.



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tial source of trouble because it may function incorrectly.

3. Complexity of many instruments, controls, alarms and lights requires a considerable training period for operators, especially if the mechanical and electrical men have to substitute for each other. With two mechanical men and one electrical man in a control room, this substitution might easily be required.
4. Added cost, due to either duplication of controls, or longer runs of instrumentation and control leads and the space required for them.

Mr. Mallory agreed, however, that the number of controls that one man can handle may be increased safely to some extent by logical arrangement and use of different types of control handles for different types of control, so that routine adjustments become simplified and, in emergencies, the operator acts from habit without having to think out each step of what he should do. "There is a need," he said, "for miniature mechanical instruments comparable to those on electrical boards or to those used for large airplanes. Furthermore, for ease and reliability of operation, the instruments and controls should be segregated to permit manipulating the vital controls from a central point with those having minor manual adjustments for efficiency and the historical items located at some less strategic point."

The advantages of complete centralized control, with the switchboard located in the control room, include:

1. Presentation of all pertinent data to one operator to give a better understanding of the plant as an integrated coordinated unit.
2. Ability of operator to take corrective action simultaneously for two or more operations, should conditions demand.
3. Avoidance of communication errors.
4. Improvement in quality of operation (better operating conditions of the centralized control room attract higher type personnel). This means more than better thermal efficiency as it should give better maintenance of load during upset conditions, quicker restoration after an interruption, and better judgment in preventing an interruption.

Obituary

Samuel Ferguson, chairman of the board of the Hartford Electric Light Company, died on February 10 at Lake Wales, Fla. He was 75 years old. Following some years with General Electric Company he became associated with the Hartford Electric Light Company in 1912 as vice president and succeeded to the presidency in 1924, retiring from that position in 1946 to become board chairman.

Mr. Ferguson was at one time president of the Association of Edison Illuminating Companies, a trustee of the Edison Electric Institute and a director of numerous companies. He was awarded an honorary degree of doctor of engineering by Rensselaer Polytechnic Institute in 1936.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

The Design of Marine Water-Tube Boilers

By L. Baker

The book is written around British practice, yet includes much that is fundamental to any boiler design. This is true particularly of the first six chapters which cover heat transfer by conduction, radiation, convection, condensing films, evaporating films and by fluid flow. In addition to the theory concerning these factors, many design data and curves are included, these having been drawn from both British and American sources.

The next twelve chapters are largely descriptive of British-built boiler types, auxiliaries and appurtenances; whereas the last third of the book deals with coal and oil firing, refractories and insulation, boiler water treatment, feed control, circulation analysis, and the installation of boilers. Numerous examples and typical calculations are included.

The author is a retired commander of the Royal Navy and is at present superintendent engineer of Alfred Holt & Co.

There are more than 400 pages, 6 × 9 in., with 257 illustrations, and the price is 45 shillings (present value $7 delivered).

Welding Handbook Third Edition

Publication of the Third Edition of the Welding Handbook has just been announced by the American Welding Society. This book, which has been recognized as the most complete and authoritative source of information on welding, represents more than four years of effort and the experience of more than 250 experts who have contributed their personal knowledge and experience and the knowledge, experience and results of research of their companies in their respective fields.

No effort has been spared in providing useful up-to-date information in readable form. The Handbook is intended to be equally useful as a text on welding and as a reference book. Suggestions obtained from a nation-wide survey of users of the earlier editions have been incorporated to provide the data most needed by the welding industry.

Twenty-seven chapters are devoted to the more than thirty welding and cutting processes used in industry today. Information on each process covers the equipment used, the basic principles of operation and the application of the process for different metals and different industrial applications.

Thirteen chapters contain information on the ferrous and nonferrous metals commonly welded, including their general properties, how to weld them with the different welding processes and their use by different industries. Metals covered include iron, wrought iron, carbon and low-alloy steels, chromium steels, chromium-nickel steels, manganese steels, aluminum, magnesium, copper and nickel and their alloys, lead, zinc, clad steels and applied liners.

A group of eleven chapters contains information on design, material, workmanship and inspection requirements for industrial applications such as aircraft, bridges, buildings, railroads, storage tanks, pressure vessels and boilers, ships, automotive products, pipe lines, industrial piping and machinery.

Additional individual chapters are devoted to data for estimating costs, physics of welding, welding metallurgy, a dictionary of welding terms and definitions, general engineering tables for shop and office use and welding standards, including welding symbols, filler metal specifications and standard tests for welds.

The format is new, each page being set in two columns which makes easier reading, and a bibliography is included at the end of each chapter listing the important codes, standards, books and technical articles on the subject of the chapter.

There are 1650 pages, cloth bound and fully illustrated. The price is $12 per copy in the United States and Canada, and $13 elsewhere.

Principles and Practice of Flow Meter Engineering

By L. K. Spink

Published by The Foxboro Company, Foxboro, Mass., this handbook appears in a new and enlarged edition, the seventh since the book was first published in 1930. Much new and valuable material has been added, making it an authoritative treatise on all phases of flow engineering. In the present edition, a new section is contributed by R. L. Parshall, inventor of the Parshall Flume, giving design details, operating instructions, and tables for measuring flows through open channels by means of weirs and flumes. Its 416 pages include all the necessary information for calculating an orifice, flow nozzle, venturi tube, pitot tube, or even a pipe elbow used for flow measurement. The common pressure tap locations are discussed, and data given to correct for odd tap locations. Liquids, steam or other vapors, and gas are handled in separate sections. Instructions, curves and tables are presented in logical sequence and simple manner. Viscosity corrections are furnished in convenient form.

Equations and curves for calculating throttling orifices to be used at critical pressure drops are a new addition to the book. Other new features include a complete section on measurements of fluid flow in metric units, a table of corrections for barometric pressures, a table of pressure multipliers up to 5000 psig, a description of practical methods of applying A.G.A. Gas Measurement Committee Report #2, new and simplified instructions for use of the square-root planimeter on gas meter charts, and pages of examples of typical calculations in flow meter engineering. The price is $7.

Heating Values of American Coals

The average heat content of the various coals produced in the United States are listed in an information circular issued by the Bureau of Mines. These heating values, compiled both by rank, or class, and according to the 27 states in which they were mined, are useful in making general comparisons between the different coals, and between coals and other fuels.

The calculations are based almost entirely on tipple and delivered samples, rather than mine samples, and the averages are thus indicative of coal that has actually been mined.

All ranks of coal from anthracite to lignite are included in the study. The average heat content of all the coals is 13,000 Btu per lb. The average value for Pennsylvania anthracite is 12,750 Btu, for lignite it is 7000 Btu, and for low-volatile bituminous, 14,200 Btu.

The circular also lists numerous technical papers previously issued by the Bureau containing chemical analyses of coals, with data by counties as well as states.

A free copy of Information Circular 7538, "Average Heating Values of American Coals by Rank and States," by George J. Flynn, Jr., former Bureau fuel engineer, may be obtained by writing to the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa.

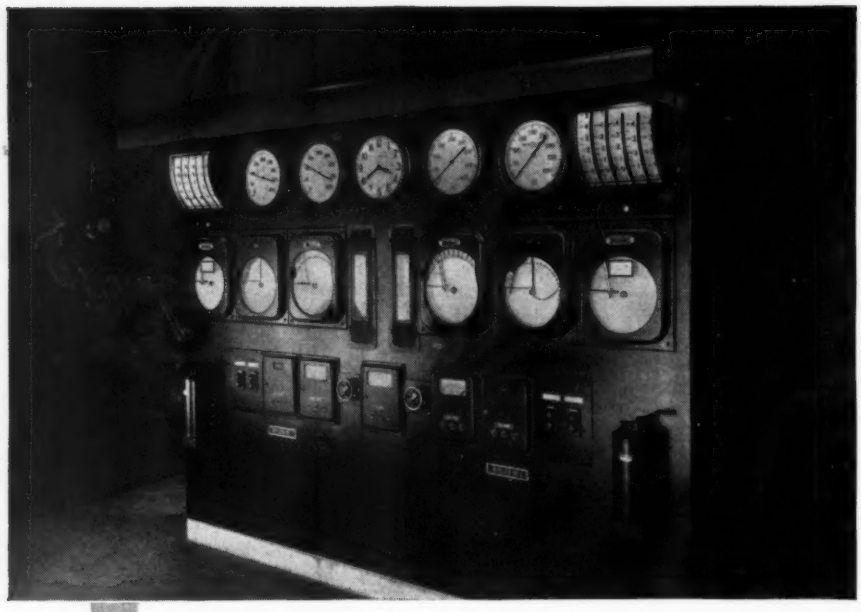
Map of U. S. Electric Facilities

The Federal Power Commission has published a map showing the principal electric transmission and generating facilities in the United States. The seven-color map, printed on a scale of approximately 60 miles per inch, shows high voltage lines of 33,000 volts or more as well as some of lower voltage in less congested areas.

Electric utility generating stations of 1000 kilowatts or more, and industrial generating stations of that same capacity which are interconnected with electric utility systems, are indicated. For the more congested areas, however, some of the stations under 5000 kilowatts are not shown.

A list of power plants printed on the side margins, arranged alphabetically by states and keyed to numbers within the plant symbols, gives the plant name, generating capacity in thousands of kilowatts, and the frequency of the generators when other than 60 cycles.

Ownership of electric facilities is indicated by an alphabetical list in the lower margin keyed to an abbreviation of the



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combustion control

QUICKLY PAID FOR ITSELF

How to get more steam to meet the demands of steadily increasing production, with all three boilers in continuous operation: that was the problem at General Mills' plant in Paris, Illinois.

A Hays Automatic Combustion Control System with full instrumentation was installed—and the problem ceased to exist. Production went up sharply from 12,500 bushels per day using three boilers, to 22,500 bushels per day using only two boilers—with the third for standby. Combustion is smokeless, velocity of gases was reduced, operating pressure is higher and turbine steam consumption dropped 1000 pounds per hour. CO_2 averages 15 percent as against the previous 7 percent; boiler efficiency rose from 55 to 78½ percent. Steam costs dropped sharply. The Hays system quickly paid for itself.

Records like this of Hays performance are not exceptional; and indicate that it's good business to *find out* about this modern electrical system, to investigate *what it will accomplish for you* in improved production and lower costs.

Talk over your plant's steam requirements with a Hays engineer—no obligation, of course. And write for Publication 47-605: worth reading.

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company name appearing adjacent to the facilities on the map. The relative capacities of the facilities, as related to the voltage level of lines or kilowatt capacities of generating stations, are differentiated by use of colors.

The map, entitled "Principal Electric Facilities in the United States," is approximately 44 by 64 inches in size. The information is based on reports filed with FPC by electric utilities through June 30, 1948. Copies of the map, at $6 each, can be obtained from the Publications Section, Federal Power Commission, Washington 25, D. C. The order number is FPC-M-11.

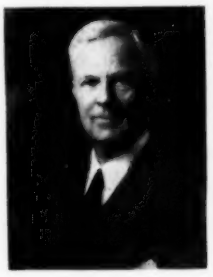
Engineering Papers of Hydraulic Institute, Vol. II

This 60-page booklet contains four papers that were among those entered in the Fourth Engineering Essay Contest of the Institute. They deal with "Cavitation in Centrifugal Pumps," "The Centrifugal Pump in the Process Industries," "Submergence for Centrifugal Condensate Pumps" and "Operation of Centrifugal Boiler Feed Pumps," each written by a specialist in the respective subjects.

The size of the booklet, 8½ × 11 in., has made it possible to include numerous plates containing working characteristic and performance curves, as well as instructive sketches; and the text is replete with useful operating information. The price is $2.

Combustion Engineering-Superheater Heads

At a special meeting of the Board of Directors of Combustion Engineering-Superheater, Inc., Samuel G. Allen, formerly vice chairman, was elected chairman of the board to succeed the late Frederic A. Schaff. Mr. Allen is identified, as an officer or director, with several other companies, including the Franklin Railway Supply Company, Lima-Hamilton Corporation, G. M. Basford Company, and The Lummus Company.



S. G. Allen

J. V. Santry

Joseph V. Santry, long president of Combustion Engineering Company and its successor, Combustion Engineering-Superheater, Inc., will also serve as chief executive officer in general charge of operations.

Personals

William F. Ryan has been elected vice president of Stone & Webster Engineering Corporation, Boston. Long associated with that Company, he will continue to be responsible for activities of its engineering department.

W. F. Crawford, president of Edward Valves, Inc., has been elected a director of the Central Scientific Co. of Chicago, manufacturers and distributors of scientific apparatus.

R. R. Popham has opened a consulting engineering office at 103 Park Avenue, New York, which will specialize in the design of steam power plants, industrial buildings, air conditioning and heating.

Titus G. LeClair, assistant chief electrical engineer of the Commonwealth Edison Co., Chicago, has been nominated to succeed James F. Fairman as president of the American Institute of Electrical Engineers.

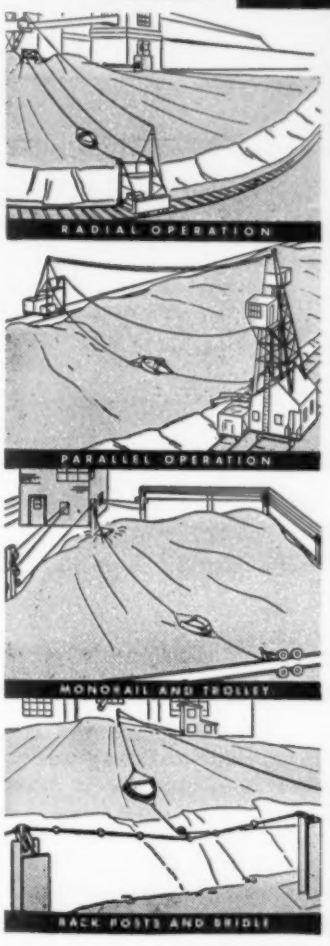
Harry S. Rogers, president of the Polytechnic Institute of Brooklyn, has been elected chairman of the Engineers' Council for Professional Development. He is a past president of the American Society for Engineering Education.

Wilfred Sykes, chairman of the Executive committee of Inland Steel Company, was the recipient of the Washington Award from the Western Society of Engineers on February 27.

William A. Wilson has been appointed associate professor of mechanical engineering at the Massachusetts Institute of Technology. A 1934 Columbia graduate, Professor Wilson's background includes six years with Westinghouse as experimental engineer on steam turbines and eight years with the Elliott Company, largely on gas turbine development work.

Sanford K. Fosholt has become chief engineer and **Franklin M. Swengel** head of the mechanical section of The Stanley Engineering Company of Muscatine, Ia. The former joined the company in 1938 after graduation from Iowa State College, and the latter was with Sargent & Lundy of Chicago for three years prior to joining the Stanley organization.

Carl E. Miller, formerly technical advisor in research and development on coal, gas and petroleum technology at Battelle Memorial Institute, has joined the Industrial Department of Combustion Engineering-Superheater, Inc. Prior to becoming associated with Battelle, Mr. Miller's experience included eight years with the Potomac Electric Power Company, three years with the Northern Indiana Public Service Company and, during the war, assistant chief of the utilities branch of the Office of Chief Engineer, War Department.



Small as well as large coal storage problems are solved economically with a

SAUERMAN POWER SCRAPER

While the big Sauerman installations attract the most attention, it should be remembered that these power drag scraper machines also are made in small and medium sizes to render economical service in storing and reclaiming relatively small tonnages of coal on limited ground areas.

For instance, note the Sauerman installation pictured above. At this power plant, the only space available, for storage was a narrow area of irregular shape, 193 ft. long on its longest side. It was necessary to arrange storage for at least 8,000 tons of coal on this space and to provide a means of storing and reclaiming at a rate of 75 tons an hour.

After studying the requirements, the engineers decided the correct solution was a 1½ cu. yd. Sauerman scraper machine equipped with a monorail and trolley. To increase the storage capacity, an 8-ft. concrete wall was built, enclosing the area on three sides. This wall supports the monorail. The scraper tail-block is attached to a trolley riding on the monorail and the trolley is moved by cables controlled by a winch placed alongside the scraper hoist. Thus the operator has at his finger-tips the means of shifting the scraper bucket instantly to any spot in the area.

The chief engineer and other officials of the company are highly satisfied with the solution of their problem. The cost of the entire installation was more reasonable than expected while the operating and repair expense has proved pleasingly low.

4 TYPES OF SAUERMAN DRAG SCRAPER UNITS

Sketched above are four Sauerman scraper machines. These four machines, suitably modified and adapted to each individual project, are the basic machines with which Sauerman engineers solve most of the problems in open storage of coal.

Long-Time Users of Sauerman Scrapers Lead in Placing Repeat Orders

Perhaps the best evidence of the satisfaction given by Sauerman scrapers is found in the impressive list of companies—leading public utilities, chemical companies, metal refineries, paper mills, coal mines, rubber factories, cement mills, etc.—that have ordered one after another of these machines through the years to handle storage projects at different locations.

At one plant a company will have a Sauerman machine that has been operating twenty years or longer and at another plant this same company will have a Sauerman installation purchased only last year. It is the record of these old machines, as much as the record of the new Sauerman equipment, that produces the steady flow of repeat orders.

Operator Stationed in Comfortable Cab has Push-Button Control of Every Move of Scraper.

Advice and literature freely supplied. Ask for Sauerman Catalog 19-D and tell us about your coal storage problems.

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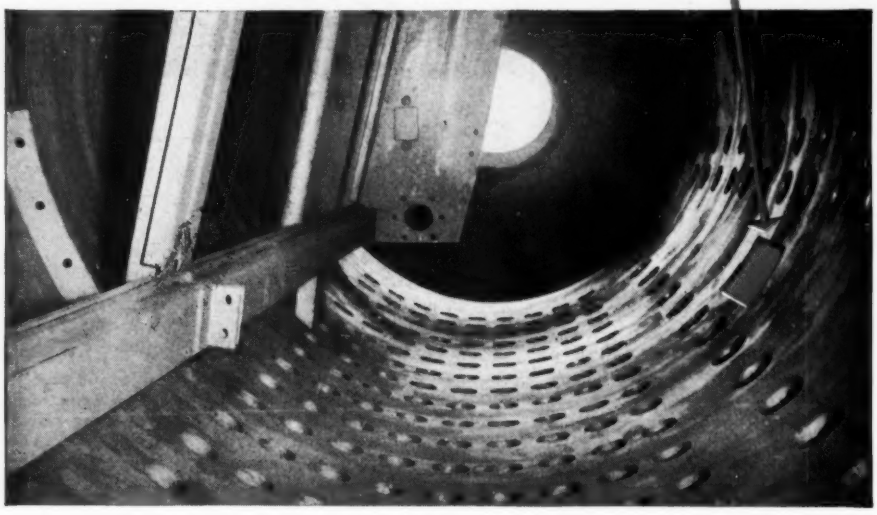
WHEN TO STOP BOILER CLEANING

. . . START BOILER COATING



What is clean tube and drum steel?

You can, of course, define it in a specification so that you have — on paper — a perfect surface. Actually, you take the word of the man inside your boiler that he's "down to bare metal" — depend on his interpretation of your meaning . . . his judgment of results. Cleaning sometimes stops short of desirable preparation — or continues beyond it at needless labor cost.

Now a simple test, accomplished in minutes, gives you *fact* — not opinion — in a positive "yes" or "no" answer to the question: Is this boiler clean? At the red signal, you stop surface preparation safely, surely. For here is base metal at its best — free from corrosion-breeding impurities and heat-transfer barriers . . . ready for the surfacing that seals it permanently at peak efficiency.

Power-driven brushes carry APEXIOR NUMBER 1 swiftly through tubes — hand brushes apply it to drums — and another APEXIORized boiler is ready for service . . .

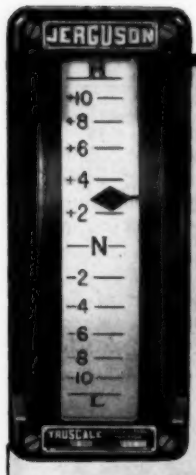
— secured against corrosion because APEXIOR is insoluble in any boiler water, unaffected by steam at any pressure or temperature.

— guarded against excessive deposit formation because APEXIOR smooths steel for easier, less costly cleaning; prolonged heat-transfer efficiency; positive inspection; uniform heat distribution; better evaporation; and improved circulation.

Making good boilers better — at less cost — is a continuing aim of Dampney Maintenance for Metal . . . protective surfacing for specialized industrial needs.

DAMPNEY Maintenance for Metal

THE DAMPNEY COMPANY of AMERICA • Hyde Park, Boston 36, Mass.



Assures Positive Distance Reading of Liquid Levels

JERGUSON TRUSCALE GAGE

THE modern design JERGUSON TRUSCALE GAGE gives new accuracy for reading of liquid levels in boilers, deaerating tanks, etc.

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New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Adjustable Speed

The General Electric Co. has prepared a series of five two-color booklets on adjustable speed, the first of which entitled "Adjustable Speed" presents a summary of benefits to be derived by industry from accurate control of drive speeds. A check list of points to be considered in selecting adjustable-speed drives is presented, and representative equipment to control speed is described and illustrated. The other four publications, entitled "Adjustable-Speed ACA Motors," "Speed Variator," "Electronic Speed Variator" and "Thymo-trol Adjustable-Speed Drives," contain descriptive and application data for the equipment, including features, advantages, operating characteristics and ratings.

Automatic Valve Specialties

Condensed catalog A-50 describes pressure regulators, automatically operated valves, pilot valves, liquid level controllers, solenoid valves and "Dia-Ball" transmission units manufactured by the Davis Regulator Co. Typical cross-sections of the various products are shown, along with dimensions and price lists. There are more than 70 pages in the catalog, which has a plastic binding.

Blowers and Exhausters

Buffalo Forge Co. has issued an eight-page catalog covering Type "E" and "RE" electric blowers and exhausters. These units are built in twelve sizes with capacities up to 5500 cfm and pressures up to 2 psig. The catalog includes performance curves, tables of capacities and static pressures, and typical dimensions.

Gages and Valves

A four-page bulletin from the Jerguson Gage & Valve Co. illustrates quick-closing valves and drain valves as well as tubular gage-glass protectors and gage illuminators. Special features of these products are described and explained.

Ring-Balance Meters

A new illustrated 4-page bulletin explains how automatic compensation for pressure or temperature variations, or for both, are achieved in flow measurement of gases, liquids or other fluids with Hagan compensated ring-balance meters. There are schematic diagrams to show how corrected records are produced, and how installations may be made to indicate both pressure and temperature. Photographs illustrate meters equipped for pressure and temperature compensation.

Rotary Pumps

De Laval Steam Turbine Co. has prepared a four-page bulletin on De Laval-IMO rotary pumps. It includes cutaway drawings of six different types of pumps, along with a brief description of each. Services for which these pumps are adapted are in feeding oil burners, for pressure lubrication, and for hydraulic pressure services. Capacities range from 0.5 to 1000 gpm for pressures to 500 psig and capacities to 150 gpm for pressures to 1500 psig.

Rotary Strainer

The Balmar Self-Cleaning Rotary Strainer is described in a four-page bulletin issued by the Balmar Corp., a subsidiary of Franklin Railway Supply Co. Designed for use with steam, air, gas, water, gasoline, light oil or heavy oil, the strainer may be operated on working pressures from 50 to 500 psig. The bulletin mentions features and advantages of the rotary strainer, provides specifications, and has a table listing approximate weight and dimensions.

Magnesium Anodes

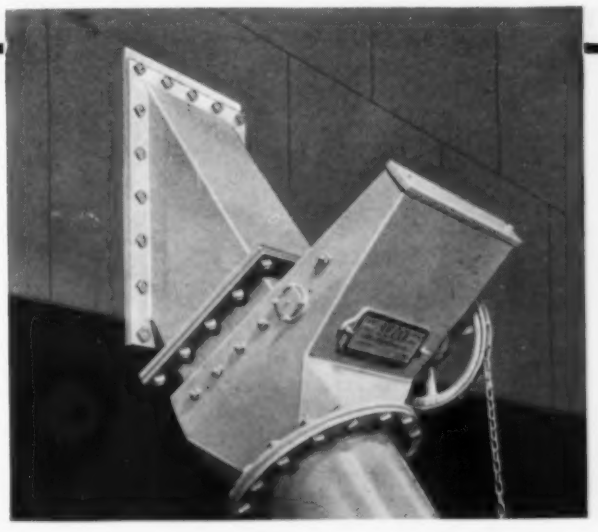
Means to control corrosion on underground and submerged structures are described in a 16-page brochure on magnesium anodes produced by Dowell Inc. The rôle of magnesium in controlling corrosion is explained, typical uses are cited, methods of design and relative costs are mentioned, and methods of installation are explained in this well-prepared bulletin.

Soot Blowers

A 16-page illustrated bulletin describing automatic-sequential, power-operated soot-blowing systems has been published by Vulcan Soot Blower Corp. Operating procedures are discussed in detail, and ten typical boiler installations are shown diagrammatically. Attractive illustrations add to the value of this interesting bulletin.

Turbine Lubrication

Problems of oxidation, emulsification, foaming and sludging encountered in turbine lubrication are described in a 4-page folder entitled "Turbo-Drive" and issued by E. F. Houghton & Co. There are sections describing flushing of turbine systems and properties of fortified turbine oil.



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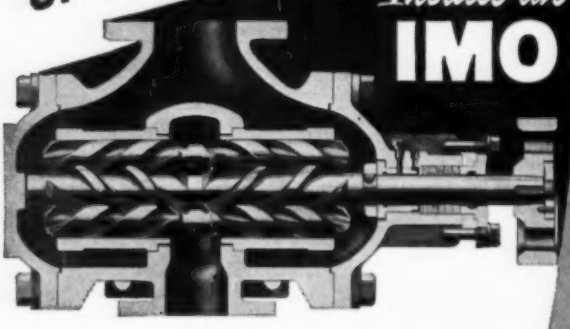

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